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AUTHOR Koenigshofer, Daniel R.
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ABSTRACT

Background information, handouts and related instructional materials comprise this manual for conducting a course on energy conservation for home builders. Information presented in the five- and ten-hour course is intended to help residential contractors make appropriate and cost-effective decisions in constructing energy-efficient dwellings. Included are five sections covering such topics as insulation, mechanical systems, cost calculations, and environmental considerations. Since major emphasis is upon the economics of energy conservation, an entire section is devoted to convincing contractors to build energy-efficient residences. (Author/WB)

Energy Conservation for the Home Builder

Course Outline and Instructional Materials

Program Development
Dept. of Community Colleges
Raleigh, N.C. 27611

ENERGY CONSERVATION FOR THE HOME BUILDER

A Course for Residential Builders

Compiled and Written by

Daniel R. Koenigshofer

Fall, 1979

for

Energy Conservation Curriculum and Short Course Project #8208
Program Development Section, North Carolina Dept. of Community Colleges

Project Director
Roger G. Worthington

Coordinators
Frank Gourley, Jr.
Peggy M. Ball

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FOREWORD

This instructional manual was prepared by the Department of Community Colleges as a part of its plan to provide occupational training courses that meet the energy conservation needs of the state and its residents. There is a need and demand for energy efficient homes. Twenty to twenty-two percent of the energy consumed in this country is for residential use. In this age of consumer education, the home buyer, with an increased awareness of energy consumption and cost, views houses with a more critical and discerning eye. The information included in this manual should help residential contractors in making appropriate and cost-effective decisions for the construction of saleable energy efficient dwellings.

Roger G. Worthington

Roger G. Worthington, Director
Program Development Section
Department of Community Colleges

Larry J. Blake

Larry J. Blake, State President
Department of Community Colleges

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CONTENTS

HOW TO USE THESE MATERIALS

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The enclosed materials have been prepared for a course on energy conservation to be taught to practicing contractors by members of the NC Community College staff who are familiar with home construction. The course will take from five to ten hours, not including field trips.

The course objectives are

- to give the builder an understanding of what an energy efficient home is, why the builder should build it, and how the builder should sell it;
- to introduce concepts of passive solar design such as orientation, overhangs, thermal mass and natural ventilation;
- to compare the different types of insulation now available, their applications, problems and costs;
- to develop an appreciation for the magnitude of heat loss from infiltration and the importance of weather-stripping and caulking;
- to develop an understanding of the operation of a heat pump - its problems and applications;
- to introduce some concepts about fireplaces, wood stoves, and good design principles;
- to discuss the applications of other energy savers such as solar water heaters, timers, water savers;
- to review the procedure for calculating heat loss from a home and to stress the importance of the calculation for sizing the mechanical systems and evaluating energy saving improvements; and
- to indicate sources of further information, assistance, and field trips.

Each of the five sections of this course has seven subsections. They are the following:

- teaching objectives
- background information for the instructor
- a list of suggested classroom activities
- handouts (graphics, pages of reference information and activities)
- slide descriptions
- a list of other references and resources

The instructor should first read the background information and examine the teaching materials. If he/she is uncertain about particular points or wants to elaborate, the references and resources will be useful. After the instructor is familiar with the materials he/she should examine the enclosed INSTRUCTOR'S OUTLINE and make any changes desired. The slides can then be ordered either according to the suggested outline or the revised outline.

In general, the handouts are ones that the instructor may want to provide to the students. Those included are keyed to the text by their number in the INSTRUCTOR'S OUTLINE. Likewise, many of the graphics provide information that would be useful for the builders to take home.

Many of the suggested activities involve an interaction among the students, the point being to emphasize that many things are being tried. Few builders will want to be the first one to experiment with a new technique; yet they will, no doubt, have many good ideas to share.

The major emphasis is on the economics of energy conservation. Thus, the entire first section is devoted to selling the contractor on the benefits of building an energy efficient home.

Slides are keyed to the INSTRUCTOR'S OUTLINE. After examining the material, the instructor may want to reorder the slides according to his/her plan. It may be useful to know that the slides are from Owens Corning Fiberglas, Carolina Power and Light, RAPCO Foam, and Integrated Energy Systems, Inc. Each community college/technical college/technical institute will receive a set of slides with initial distribution of this manual.

The students should bring calculators, pencils, paper, and a set of plans for a home which they have built or intend to build. The instructor will need a slide projector, an overhead projector, a chalkboard, and some or all of the materials listed in the ACTIVITIES subsection.

INSTRUCTOR'S OUTLINE

INSTRUCTOR'S OUTLINE

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SECTION 1

Why Build Energy Efficient Homes?

SECTION 1. WHY BUILD ENERGY EFFICIENT HOMES?

OBJECTIVE

The builder should understand why it is in his/her best interest to build energy efficient homes. After study of this section the builder should know that:

1. buyers want energy efficient homes,
2. buyers will pay more for these homes, and
3. the builder can make more money by building energy efficient homes.

BACKGROUND

Buyer Demand

Home buyers and owners are increasingly aware of the high cost of energy. As a result, they are insulating old homes and demanding good insulation in new homes. Several facts substantiate these statements.

1. Many uninsulated old homes are now being retrofitted.
2. Insulation manufacturing cannot keep pace with demand.
3. A survey of consumers by Professional Builder magazine yielded the following results:

   Q. Would you spend an extra $600 on a home if you were told you would save $100 per year on heating and cooling costs?

   A. 80.5% of buyers of single family homes said they would spend the $600; 8.9% said they would not because the pay-back was too slow; 8.2% said they would not because they didn't believe the savings estimate.

   Q. What energy conservation features are most important?

   A. In order of priority - insulation, double glass, storm windows, attic ventilation.

4. The federal and state governments have initiated measures to encourage conservation - tax incentives for use of solar systems and insulation and more stringent codes.
5. Extensive publicity in newspapers, magazines, and on TV about solar energy, energy costs, and energy shortages has increased public awareness.

6. Many builders, e.g., R. B. Fitch, Paul Trollinger, Gary Lipson, and Grady O'Neal have made energy conservation an important and successful sales feature. (See p.194, for location of builders).

First Cost

Most builders feel that energy efficient homes cost much more to build. This is not necessarily true. The following information can be used to substantiate this:

1. In general, an efficient home is slightly smaller than an old-fashioned one.
2. Energy efficient homes require smaller heating and cooling units and distribution systems (fans, pumps, ducts); one study (Reference #1)* indicated a cost savings of 11¢/sq. ft. on HVAC systems (e.g., $165 on a 1500 sq. ft. home).
3. Other areas for possible savings are reduced size of water heaters due to flow reducers on faucets; fewer studs in 2 X 6, 24" o.c. construction; fewer, better placed windows; fewer light fixtures.

Construction Problems

Many N.C. area builders think that energy efficient homes are more complicated to build. This is certainly not the case for the most important energy saving features, i.e., double glazing, good weather-stripping and caulking, poly vapor barrier, high insulation. Probably the most controversial feature is the 2 X 6 wall system. Paul Trollinger, a well-known builder in

*Thoughout the manual, "Reference" plus a number cites a reference listed in the "Other References and Resources" list that appears at the end of that particular section of the manual.

Asheboro, builds 2 X 6 walls. He feels that it adds no additional cost or problems.

On the other hand, NAHB is very skeptical about the cost/benefit of 2 X 6 walls. They feel that the problems are not worth the savings. Finally, an alternative is to use 2 X 4s staggered to provide a 6" wall.

In short, regular homes can be energy efficient if they are very well built and incorporate even simple conservation measures.

Selling Energy Conservation

In general, buyers are aware of the desirability of energy conservation and are demanding it. Most are not asking for detailed cost/benefit analyses. In fact, builders such as Fitch, Trollinger, and Lipson are not sure what the exact added cost of the energy features is; their houses simply include the features as standard equipment.

Fitch Creations distributes a list of energy features found in their homes. Their strategy is to list everything possible. Thus, the 26 item list includes such things as "white paint to improve natural lighting." In any case, always be sure to list those features which consumers are most aware of, i.e., high insulation and double glazing. The seller should also stress that an energy efficient home is a more comfortable one.

The builder should have literature available for the skeptical buyer who wants documentation, but it shouldn't be given out unless asked for. Otherwise, the technical literature may confuse the buyer and require more sales time for explanation. If the buyer doesn't ask about prices and

savings, don't volunteer it unless the statistics are very simple, graphic and overwhelmingly in your favor.

If the buyer or builder demands justification, it should be given in terms of life cycle cost or monthly cash flow. Cash flow is preferable since it eliminates the question "What if I live here for only 4 years?" (The answer is that a higher resale value means a feature does not have to pay for itself before the house is resold.)

The key to the cash flow analysis is that the additional first cost is added to the mortgage. The increase in the monthly mortgage payment then, is offset by a reduced utility bill. For example, $1000 added to a mortgage (12%, 25 years) will add $10.54 to the monthly payment. An energy saving feature should save at least this much to make it a good investment. (See Section 5 for calculating savings.) You can also point out that the mortgage interest is tax deductible whereas utility bills are not, and energy prices are skyrocketing while mortgage payments will remain fixed. Standard mortgage payment tables can be used to determine the additional monthly cost.

Life cycle analysis is slightly more complicated, but it provides a means to compare the cost of an investment to the present value of the expected savings. Interest income foregone should also be considered.

Example: Should a buyer invest $2000 of savings to insulate his/her home? Assume he/she is now earning 8% on his/her money, energy prices are expected to increase at 12% per year, the insulation is expected to last 20 years, and the insulation will save $150/year at present rates. The present

value of the life cycle savings is $4014 ($150 x 27.76). Thus, an investment of $2000 in energy conservation will produce the same return as putting $4014 into an 8% savings deposit.

The enclosed table (Handout #1) gives multipliers for calculating present value of life cycle savings for annual interest rates of 6, 8, 10, 12, 14%; lifetimes of 5, 10, 15, 20 years; and annual energy price increases of 6, 8, 10, 12, 14, 16%.

ACTIVITIES

1. Ask builders to recount their experiences selling energy conservation - buyer attitudes, e.g., particular concern about insulation.
2. Ask builders what types of sales aides have been unsuccessful.
3. Go through cash flow calculations to show how saving energy can save money on monthly payments.
4. Go through life cycle cost/savings calculations.

Excerpt from Energy Conservation in New Building Design:

An Impact Assessment of ASHRAE std. 90-75

D. CONCLUSIONS

Within the report are many findings, observations, and recommendations concerning ASHRAE 90's effect on building energy consumption, its influences on physical changes in the buildings, its implications on the owning and operating costs of buildings, its potential impact on the nation's energy consumption in construction, its possible economic impact on several selected markets and participants within the construction sector, and its impact on building habitability. The more important conclusions are as follows:

1. *Impact on Building Energy Consumption*

Under a strict interpretation of the standard, ASHRAE 90 is very effective in reducing annual energy consumption in all building types and locations. The unweighted average reduction in annual energy consumption relative to 1973 construction and operational practices across the four locations investigated were as follows:

Single-Family Residence	- 11.3%
Low-Rise Apartment Building	- 42.7%
Office Building	- 59.7%
Retail Store	- 40.1%
School Building	- 48.1%

ASHRAE 90 may be seen as less effective in reducing annual energy demand in the detached single-family residence than in the larger residential and nonresidential buildings. This lower effectiveness may be explained in part by the moderately high overall thermal efficiency assumed for the conventional residences. However, the ASHRAE 90 modified residences in both the Northeast (New York City), North Central (Omaha) locations met the standard with single glazing and a minimum reduction in glass area.

The standard appears to be more effective in the colder climates because of the larger percentage of annual energy demand in all construction accounted for by space heating and the inherent effectiveness of ASHRAE 90 in reducing annual heating requirements. In general, the decrease in space heating requirements accounted for 60 to 75% of the total reduction in actual energy consumption.

The lowest unit-energy consumption obtainable in the prototypical buildings after the prescriptive/performance approach (Sections 4 through 9) had been made was on the order of 67,000 to 72,000 Btu per square foot. This consumption is considerably greater than the General Services Administration announced "goal" of 55,000 Btu per square foot. ADL does not believe the implementation of ASHRAE 90 alone would suffice to meet the GSA goal for any building type similar to those investigated.

If measured in terms of energy reduction potential, the most "effective" sections in the document will vary by type of building. With few exceptions, all of the sections have some influence on the reduction in annual energy consumption. Changes in winter design conditions (Section 5) and supplied domestic hot water temperatures (Section 7) appear to be the most effective parameters for the single-family residence, while those chapters dealing with HVA/C equipment, systems, and control (Sections 5 and 6) appear to be most effective in nonresidential construction.

2. *Impact on Physical Characteristics*

The application of ASHRAE 90 brought about the following physical differences in the conventional versus ASHRAE 90 modified buildings:

Exterior Glass - Glass area (percent fenestration) was reduced in approximately two-thirds of the buildings. Reductions were as much as 30%, but most were less than 20%. One region--the North Central--required reductions in glass area for all buildings.

Exterior Wall - Decreases in glass area were balanced by increases in net wall area; virtually all increases were less than 8%.

Insulation - Additional insulation requirements for residential construction varied from 80 to 300 pounds per unit. Increased requirements for insulation in commercial construction were even greater than those needed in residential construction.

Lighting - Reductions in lamps and lamp fixtures varied by building type, and averaged 24% and 22%, respectively, for nonresidential construction.

HVA/C System Capacities - Reductions in heating system capacities were significant, averaging 42%, while reductions in cooling systems were generally less, averaging 31%. The greatest reductions were found in the school building. Auxiliary HVA/C equipment, including pumps, towers, fans, supply fans, etc., also showed a significant reduction, averaging 44% in rated kilowatt capacity.

3. *Impact on Building Economics*

Based on 1975 energy costs compiled by ADL, annual savings in operating costs ranged between $0.05 and $1.05 per square foot, but were generally within the range between $0.20 and $0.70 per square foot. Savings in single-family residences ($0.05 to $0.14 per square foot) were lower and less broader than those for commercial construction ($0.12 to $1.05 per square foot). Percent savings in annual energy costs ranged from 9-15% in the single-family house to 30-45% for commercial buildings.

The savings may be large enough to induce building owners to follow the standard on a voluntary basis providing they had such decision information available to them and providing financial institutions recognize that the loan quality is improved.

The initial construction costs of those buildings modified under the standard prescriptive/performance approach were shown to be <u>less</u> than those of conventional buildings. Unit savings range from $0.04 to $0.94 per square foot, with the greatest savings experienced in office buildings.

ASHRAE 90 generally increases the cost of the exterior wall, floors, roof, and domestic hot water system. Glazing costs may be higher or lower depending upon building type. Unit costs for lighting, and particularly HVA/C equipment and distribution systems, were signficantly lower and tended to offset the increase in other costs.

Average changes in unit costs are as follows:

	Dollars Per Square Foot
Single-Family Residence	- 0.02
Multi-Family Residence	- 0.41
Office Building	- 0.63
Retail Store	- 0.18
School Building	- 0.44

For the prototypical buildings investigated, the cost of additional design effort was found to be between $0.09 and $0.36 per square foot of floor area. With the exception of the single-family residence, the straight payback of design services due to energy cost savings was found to be less than one year, and less than six months in most cases. Average additional design costs were as follows:

	Dollars Per Square Foot		
	Annual Energy Savings	Additional Design Services	Straight Payback
Single-Family Detached Residence	0.07	0.24	2.9 years
Low-Rise Apartment	0.31	0.09	3.4 months
Office Building	0.40	0.16	2.5 months
Retail Store	0.68	0.09	7.6 months
School	0.70	0.15	4.6 months

Thus, savings in initial cost can be offset by increased design fees; consequently it appears that the ASHRAE 90 modified buildings should cost no more to build and will have significantly less annual energy costs. Furthermore, even if total initial cost did increase, the savings in operating cost (over those of conventionally-designed buildings) would more than recover such costs in a couple of months.

4. *National Energy Consumption*

If instituted by all states, ASHRAE 90 could reduce the annual energy consumed in new construction by about 27%, and if instituted in 1976, the standard would reduce ADL estimates of the growth of energy consumption in the building sector over the period 1976 to 1990 from 2.3% to 1.4%.

The potential energy which could be saved by the adoption of ASHRAE 90, equals 4%, 8%, and 12% of total estimated annual energy consumption in the nation's buildings for the years 1980, 1985, and 1990, respectively. However, the standard will not cause a decline in the nation's future demand for energy in the building sector.

The potential energy saved by ASHRAE 90 was found to be greater in the North Central region, and again, this is related to the annual demand accounted for by space heating.

ASHRAE 90 could reduce energy consumption significantly even if it were adopted (and enforced) only by those 29 states that presently have mandatory or voluntary statutes or that have bills pending, since 75% of the volume of affected construction lies within these 29 states.

5. *Impact on Building Materials and Building Equipment Markets*

Of the estimated $168.5 billion in construction expenditures in 1976, the study estimates $88.3 billion, or 52%, could be affected by ASHRAE 90. Of this, $80.0 billion is construction put-in-place, and $8.3 billion is attributable to mobile homes.

ASHRAE 90 would upgrade the building's thermal shell, lower lighting and ventilation levels, and reduce HVA/C equipment capacities. The direct economic impact attributable to ASHRAE 90 appears to be limited to a few specific industry sectors. (See Table I-1.) In general, the adoption of ASHRAE 90 will create opportunities for suppliers of commodity building materials at the expense of reducing those markets for general building equipment and HVA/C systems.

The most favorable impact appears to be on building insulation suppliers, who could realize as much as $179 million in new markets, an increase in their overall annual sales of approximately 18%. Likewise, HVA/C equipment manufacturers face an annual potential loss of $185 million, 8% of their total market, while lighting fixtures manufacturers

TABLE I-1

SUMMARY OF ECONOMIC IMPACTS DUE TO ASHRAE 90

	Total Annual Market ($MM)	Market Affected by ASHRAE 90 ($MM)	Market Affected by ASHRAE 90 (%)	Maximum Potential Impact by ASHRAE 90 ($MM)	Percent of Total Market (%)	Percent of Affected Market (%)
Building Materials Suppliers:						
Insulation:	1,000	595	(60)	+179	+18	+30
• Batt	470	270	(57)	+ 45	+10	+17
• Rigid Board	460	280	(61)	+128	+28	+46
• Loose Fill	70	45	(64)	+ 6	+ 9	+13
Siding Materials	1,000	850	(85)	+ 12	+ 1	+ 1
Flat Glass	1,247	146	(12)	+ 7	+ 1	+ 5
Windows	903	720	(80)	- 19	- 2	- 3
Building Equipment Manufacturers:						
Electric Lamps	1,177	176	(15)	- 16	- 1	- 9
Lighting Fixtures	1,450	830	(57)	-175	-12	-21
Gas and Electric Meters	173	159	(92)	+ 3	+ 2	+ 2
Hot Water Heaters	289	117	(40)	+ 4	+ 3	+ 3
HVA/C Systems Manufacturers:						
HVA/C Equipment	2,308	1,720	(75)	-185	- 8	-11
HVA/C Controls	550	410	(74)	+ 21	+ 4	+ 5

SOURCE: Arthur D. Little, Inc., estimates.

face a potential loss of $175 million, 12% of their total market. The remaining market sectors will receive only a minimal impact, typically ranging from -2% to +4% to their annual market.

HVA/C equipment manufacturers, unlike commodity materials suppliers, are heavily oriented towards new construction. Few, if any, large secondary markets are available to HVA/C component suppliers that can offset a major loss in the potential sales volume from conservation-oriented design. Although manufacturers may be able to moderate this negative impact, they will nevertheless be adversely affected by any type of effective energy conservation legislation, be it ASHRAE 90 or some similar design standard.

Most of those companies associated with the construction industry have experienced other sudden and significant impacts on their markets and still survived. The situation investigated here is comparable to those sudden annual downturns resulting from annual residential cyclicality or safety-oriented fire modifications. ADL anticipates these sectors will again be able to adapt.

6. *Impact on Key Industry Participants*

The study concludes that the successful implementation of ASHRAE 90 will have an insignificant impact on residential homebuilders. Large builders can meet the standard at an insignificant design cost, and the small, local builders--while initially experiencing difficulty in interpreting the document--will probably be assisted by the local Homebuilders Association or building materials suppliers through manuals of accepted practice.

Wise builders seeking profit opportunities on sales may well use the energy crisis as a sales tool to sell extras, but these, for the most part, will have to be visible.

The adoption of ASHRAE 90 will tend to load-up the "front end" of the design process. It will result in more calculations, further technical and economic evaluation of systems, additional internal and external meetings of the design team, and more interaction with code authorities. This effect on the design process need not affect the project schedule, provided that the mechanical engineer is included in the design team at the very beginning.

ASHRAE 90 will generally encourage the use of electronic computation on all projects, and thereby create a major market for energy-oriented computer programs and services.

Total A/E design billings in 1976 are estimated to be $7.4 billion, approximately 40% of which could be affected by ASHRAE 90. The net impact of adopting the standard would be a potential increase of $92 million in billings for mechanical/electrical engineers and $60 million

for design architects. It seems likely that the A/E's ability to collect for additional services will depend strongly upon the health of the construction industry at the time.

Perhaps more than any previous event in the design industry, the advent of ASHRAE 90, or some similar standard, will demand a major overhaul in the industry's fee structure, particularly for mechanical/electrical design engineering services which historically have been based on a percentage of the mechanical systems cost of the project.

From a professional standpoint, possibly the most significant impact of ASHRAE 90 is that the design engineer will become a more important and integral member of the design team.

Concerning code authorities, ASHRAE 90 faces two problems: implementation and enforcement. It would not be surprising if a standard dealing with an abstract objective--achieving national energy self-sufficiency--were not to succeed, since more concrete concerns with such visible problems as consumer and third-party health and safety have failed to motivate institutional change and code effectiveness. Those institutional barriers that have so far prohibited the adoption of a model code on a more limited basis, will continue to create barriers for the implementation of ASHRAE 90 or allow it to be implemented only in cannibalized form. These problems could be moderated with financial or economic arguments.

Experience has shown that, because of limited resources, manpower, and commitment, enforcement of state codes is weak. ADL concludes that a combination of financial incentives, probably built into the utility rate structure and tied to the implementation of energy-conserving construction methods, and of penalties aimed at the energy user to achieve the same results, must be actively considered if energy conservation in building design is truly to be achieved on a widespread basis. An alternative, not investigated here, is to encourage long-term financing institutions to demand energy efficient structures.

7. *Impact on Building Habitability*

The principal impact of ASHRAE 90 on the health, safety, and welfare of building occupants will result from reduced ventilation and infiltration called for in the standard. Reduced humidity in winter will lead to some discomfort, but with the exception of certain medical facilities, no health hazard would result.

The standard is likely to increase greatly the importance of indoor air pollution sources, and to result in excessively increased exposures of nonsmokers to cigarette smoke particles, increased complaints about odors, and demands for separate smoking and nonsmoking areas. Additional similar problems are expected to arise under ASHRAE 90, though insufficient data are available to permit quantitative evaluation of these problems at this time.

HANDOUT #2

PRESENT VALUE AND LIFE CYCLE COST MULTIPLIERS

	Escalation in Energy Prices					
	6%	8%	10%	12%	14%	16%
Interest Rates						
5 year life						
6	4.72	4.90	5.09	5.28	5.43	5.69
8	4.46	4.63	4.80	4.99	5.17	5.37
10	4.23	4.38	4.55	4.71	4.89	5.07
12	4.01	4.16	4.31	4.46	4.63	4.79
14	3.81	3.95	4.09	4.23	4.39	4.54
10 year life						
6	9.43	10.28	11.21	12.24	13.38	14.62
8	8.52	9.26	10.07	10.97	11.95	13.04
10	7.74	8.38	9.09	9.87	10.73	11.68
12	7.06	7.62	8.24	8.93	9.68	10.51
14	6.46	6.96	7.51	8.11	8.77	9.50
15 year life						
6	14.15	16.18	18.58	21.40	24.73	28.66
8	12.23	13.89	15.84	18.14	20.84	24.01
10	10.66	12.03	13.64	15.52	17.72	20.30
12	9.37	10.51	11.84	13.39	15.20	17.32
14	8.30	9.26	10.37	11.66	13.16	14.90
20 year life						
6	18.87	22.67	27.44	33.46	41.07	50.68
8	15.60	18.52	22.17	27.76	32.48	39.69
10	13.08	15.36	18.81	21.69	26.07	31.55
12	11.13	12.92	15.13	17.86	21.24	25.44
14	9.58	11.01	12.76	14.91	17.54	20.80

SLIDE DESCRIPTIONS*

1 1. Title Slide.

1 2. Credit Slide.

1 3. Acknowledgement Slide.

1 4. Twenty-five million homes have no insulation, but they are being retrofitted rapidly as energy costs go up. People are aware of need.

1 5. Old attic insulation. Techniques have improved greatly.

1 6. Number pounds insulation per house - 1967-80, increasing rapidly.

1 7. Average pounds insulation per retrofit increasing.

1 8. Insulation production capacity utilization. Plants are producing maximum, but demand is so high there are shortages.

1 9. Housing starts in 1,000's. In addition to increased awareness, housing starts are up substantially.

1 10. 750,000 homes were retrofitted with insulation in the first half of 1976. Three million homes were retrofitted with insulation in the first half of 1977.

1 11. Infra-red photo of roof before insulating ceiling, as shown in TV commercial.

1 12. Infra-red photo of roof after insulating ceiling.

1 13. Insulated homes have higher resale value, but payback is not the only criterion for installing energy conservation features.

1 14. 80% of buyers would spend $600 to save $100/year according to a survey by Professional Builder magazine.

1 15. Ten areas for energy saving from Owens Corning Fiberglas.

1 16. Detail of 2 X 6 wall framing, 24" o.c. Use good, straight studs to minimize warping of sheetrock. Materials cost is about same as for 2 X 4.

1 17. Detail of corner framing in 2 X 6 wall.

1 18. Detail of header framing in 2 X 6 wall.

1 19. Prefab trusses under north sloping shed roof. This allows adequate space for insulation and ventilation. (Solomon & Reuben Builders.)

*See page 3 for information on obtaining slides.

OTHER REFERENCES AND RESOURCES

1. Little, Arthur D. Energy Conservation in New Building Design: An Impact Assessment of ASHRAE Standard 90-75. U.S. Federal Energy Administration PB-252-639. Washington, DC: U.S. Government Printing Office, 1976.

   Good analysis of the costs and savings on constructing energy efficient residential and commercial buildings compared to average construction.

2. Designing, Building, and Selling Energy Conserving Homes, No. 560.01. Washington, DC: National Association of Home Builders, 1976.

   A massive compendium of very good information and booklets. Available for $30 from NAHB, 15th and M. Streets, NW, Washington, DC 20005.

3. A Pocket Guide to Selling EEH, No. 15-BL-7548. Toledo, Ohio: Owens-Corning Fiberglas.

   A small card discussing energy cost projections, savings potential versus mortgage costs.
   Available from Owens-Corning Fiberglas, Fiberglas Tower, Toledo, OH 43659 or from local Owens-Corning office.

4. Buying a New Home? How to be Sure You Get Your Money's Worth in Insulation, No. 77-RCI-08. Toledo, Ohio: Owens-Corning Fiberglas.

   Available from Owens-Corning Fiberglas (address above).

5. Energy Efficient Home-Criteria Checklist, No. 5-BL-7625. Toledo, Ohio: Owens-Corning Fiberglas.

   Available from Owens-Corning Fiberglas (address above).

6. How to Use the OCF Energy Savings Line, No. BL-7196-B. Toledo, Ohio: Owens-Corning Fiberglas.

   Available from Owens-Corning Fiberglas (address above).

7. The Common Sense House. Raleigh, NC: Carolina Power and Light Company.

   A one page flyer showing energy conservation home diagram and discussing cash flow concept.
   Available free in quantities up to 200 from CP&L, Customer Service, P.O. Box 1551, Raleigh, NC 27602.

SECTION 2

Environmental Considerations:
Solar, Climate, Site

SECTION 2. ENVIRONMENTAL CONSIDERATIONS: SOLAR, CLIMATE, SITE

OBJECTIVE

The purpose of a home is to protect its occupants from inclement weather and to keep them comfortable. The builder needs to understand climatic factors in order to build a comfortable, efficient home. After this section the contractor should know the following:

1. how to site a home to take advantage of seasonal solar movements and wind patterns,
2. how to calculate sun angles and size overhangs for shading,
3. the value of and how to protect shade trees,
4. why and how to lay out a subdivision to utilize solar energy, and
5. how to lay out the interior of a home to best utilize natural environmental factors.

BACKGROUND

Solar Movement

The essence of passive design is recognizing what the sun is doing in various seasons and how it can best be used to keep the home comfortable. In summer, the north-south axis of the earth tilts toward the sun which causes the sun to rise high in the summer sky. At noon in mid-June the altitude is 78°. Conversely, the earth tilts away from the sun in winter. In mid-December the sun reaches a maximum altitude of only 31° above the south horizon. This change in altitude of 47° from winter to summer can be used to heat the home in winter and keep it cool in summer.

The figure in Handout #3 shows how the low winter sun passes deep into a house through the south glass. Yet, as shown, the overhang shades the glass entirely from the summer sun.

Sun angles can be determined for every hour in any season with a Sun Path Diagram. Enclosed Handout #4 is a diagram for 36°N. It can be used for any location in North Carolina with only a few degrees error. A sample calculation is given. From the solar angle, we can determine many things such as:

1. proper length of overhang to provide summer shade;
2. distance sun will penetrate a home;
3. possible shading of south glass or solar collectors by trees or other buildings.

All of these can be found using basic trigonometry. The diagram in Handout #3 shows solar angles for North Carolina.

Passive Solar Heating

Passive solar heating concepts are being integrated into many homes. Any house which has the majority of its glass on the south side will receive a considerable amount of winter solar heating. In fact, a well-insulated home with good solar exposure may overheat on a clear, cold winter day. This is not a big problem since the windows can be opened to cool the house. This will, however, waste heat that would be useful after sunset. The problem can be overcome by placing thermally massive materials in the house. These massive materials (concrete, brick, soil, water, stone) warm slowly during the day and cool slowly at night. Thus, they effectively store daytime excess heat and give it back at night. Ideally, the massive material should be on the south side of the house where the sun will strike it directly.

In a typical winter in the Piedmont, a square foot of south facing double glass will collect about 100,000 BTU's more during daytime hours than it will lose at night. At present prices, that's about $1 of free heat per year per square foot. This net gain can be greatly improved by using insulating shutters to keep the heat from escaping at night.

Greenhouses are becoming very popular. Depending upon their construction and orientation, however, they can have a positive or negative impact on annual energy use. Ideally, the greenhouse should be attached to the house on the south side. It should have high, operable vents into the house to tap the excess heat in the winter. Thermal mass, e.g., barrels of water, in the greenhouse will store some of the excess heat to help

maintain adequate nighttime temperatures. Double glazing is needed to reduce heat loss. Finally, the greenhouse needs good ventilation to keep down summer temperatures.

Passive Solar Cooling

Passive solar cooling concepts are equally important in the summer. Actually, a good passive design is a question of avoiding summer solar heating. The table in Handout #5 shows the amount of energy which will enter a house through vertical double glass on clear days. As indicated, even unshaded south facing glass will collect only a little more heat than north glass. East and west facing glass will, however, collect about twice as much heat as south glass. West glass is the most troublesome since it collects direct sunlight in the afternoon when the ambient temperature is high and cooling loads are at their peak. In contrast, note that south glass will collect three times as much heat as east or west in January. The message is clear. Maximize south glass, minimize west in particular. The ideal passive home in North Carolina has an E-W axis which is 1.7 times longer than the N-S and has most of its glass on the south side.

Natural Ventilation

Winds in this area generally prevail from the southwest, except during August through October, when they prevail from the northeast. Contractors can take advantage of this by providing sufficient air inlet windows facing these directions, and larger air outlets on the downwind side of their homes. Maximum cross-ventilation is achieved by placing small openings on the windward side of homes and larger windows on the leeward

side (Handout #6). This causes a "Venturi effect" with resultant higher velocity air movement into the building.

Another point to stress is convection cooling. Warmer air rises; if it is allowed to escape, it will pull in cooler air. Thus, both high and low windows should be provided. Likewise, roof ridge and soffit vents are much better for cooling an attic than are gable vents.

Landscaping

Trees and other natural elements outside a home can also be used to help save energy and increase the sales value of residential property. Tree preservation makes both economic and practical sense. Deciduous trees are particularly useful, since they provide shade only during the warmer months when it is most needed, and shed their leaves to allow the winter sun through. Trees also aid natural ventilation. Since the wind channels around and under trees, the air speed is increased at ground level, increasing comfort. One study, by the Alabama Forestry Commission, concluded that tree shading of mobile homes lowered cooling costs by $45 to $100 per year. It also found that even partial shading of 20% produced measurable savings. (Reference #2)

The species of tree needed to provide protection from cold winter winds or to create shade from the summer sun should be considered. A diagram showing the most desirable locations of different species of trees can be found in Handout #7.

Interior Layout

In general, rooms used primarily during the day (e.g., kitchen, living

area) should be placed on the south side where they will be lightest and warmest in winter. Rooms used primarily at night belong on the north side. Ideally, outside storage should be provided for those items which do not require heating and cooling. Carports or garages serve best on the west side where they provide summer shading. A diagram of a simple home with well arranged rooms is included (Handout #8).

Appliances can be located to reduce energy consumption. Heat producing appliances such as ranges, ovens, or dishwashers should not be placed adjacent to the refrigerator. Adequate space should be provided to allow good air circulation around the refrigerator coils. A closeable vent to the outside should be installed over the range to remove unwanted heat. Recirculating, filtering range hoods do not remove heat. Washers and dryers should be located in unheated space as should the water heater. While the water heater will add heat in winter, you pay twice for it in summer - once to heat the water, once to cool the house.

Natural Lighting

In winter, of course, south glass lets in much more light than other orientations. It will also provide good diffuse light in summer. You should note that lighting can account for 25-40% of the air conditioning load in a home. Diffuse natural lighting provides more light and less heat than any type of electric lamp.

Windows placed high and/or in corners provide the most pleasant and effective natural lighting.

Plat Layout

Since the ideal house is longer in the E-W direction than N-S and has extensive south glass, streets should be laid out on an E-W grid if the homes are to face the streets. Actually, the house need not face exactly toward the street. In fact, a development in which the homes don't line with the street could, justifiably, be called a solar community and may be more attractive.

In order to allow good circulation of air, the setback on the homes should vary. Finally, on small lots the builder should avoid shading the south side of a home with a fence, another home, or other obstructions. A diagram showing minimum allowable separation is enclosed (Handout #3).

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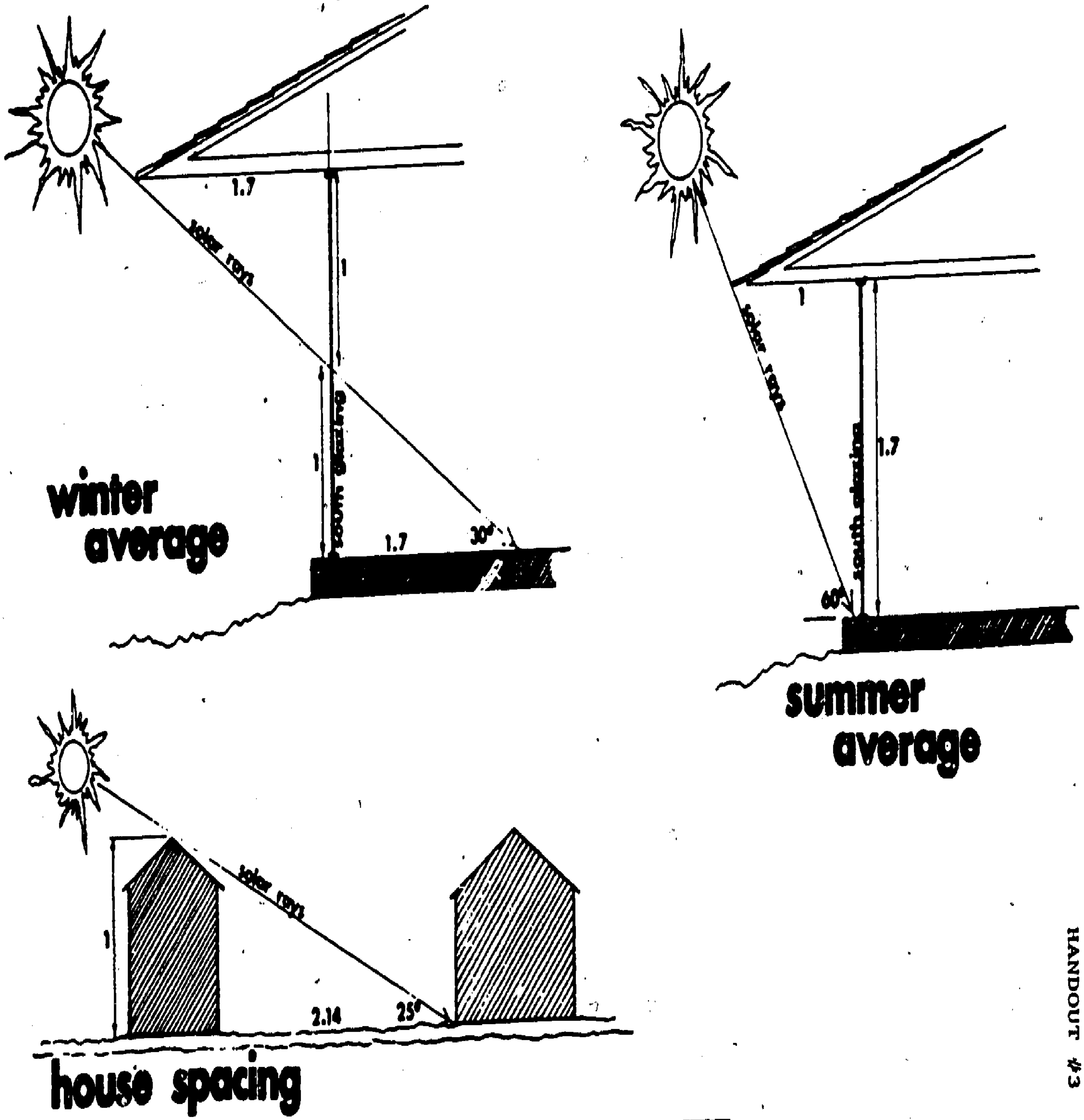
ACTIVITIES

1. Use diagram to find angle of sun at noon December 21, and June 21. Use it to show that east and west walls receive little winter sun. (Handout #4)
2. Use table to compare summer heat gain in west window versus south window. (Handout #5)
3. Take a plan for a typical tract type home and solicit ideas for small changes to redesign and reorient for passive solar design.
4. Compare a 70° triangle to a 35° triangle to show the difference between summer and winter solar angles.
5. Calculate winter heat gain through south glass. Compare to heat loss by methods in Section 5.
6. Use a flashlight and a model of a home to show the effects of orientation on sunlight penetration.



HANDOUT #3

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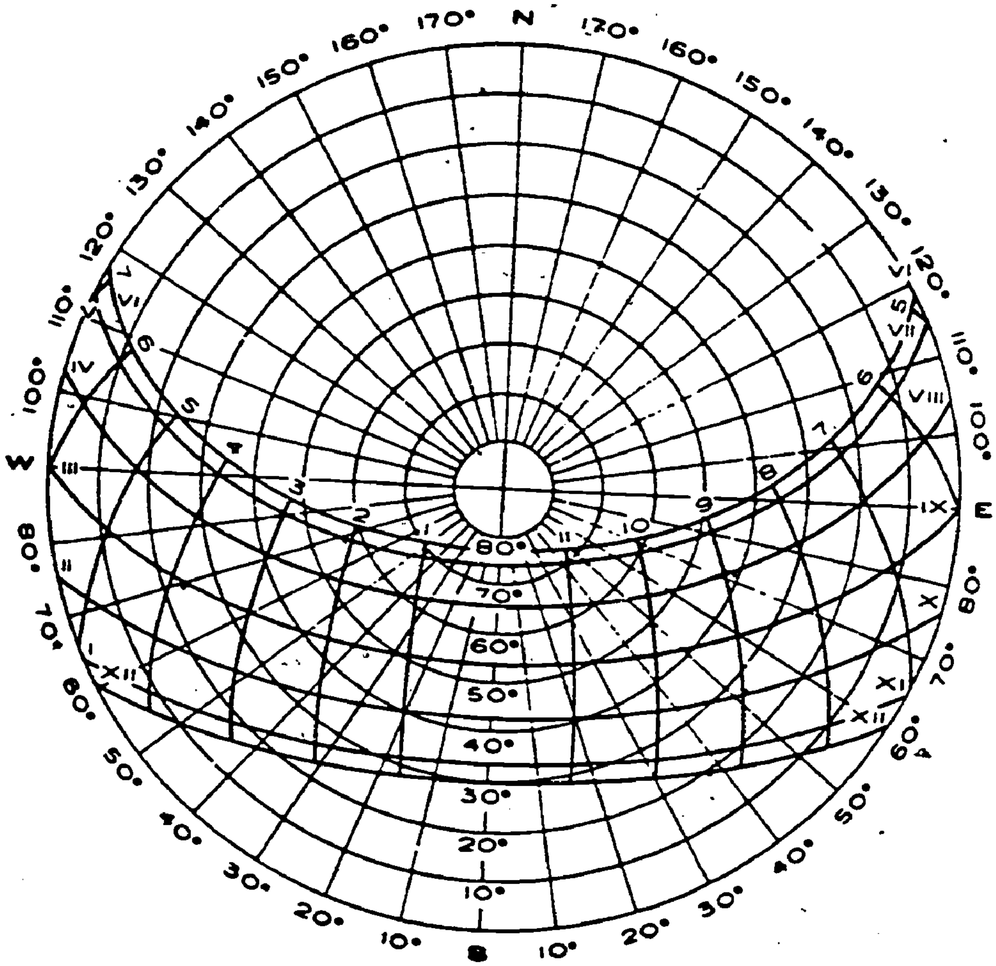
SOLAR ANGLES IN NORTH CAROLINA

igned for: The North Carolina Department of Community Colleges by: integrated energy systems Chapel Hill North Carolina 27514

SUN PATH DIAGRAM FOR 36°N LATITUDE HANDOUT #4



EXAMPLE

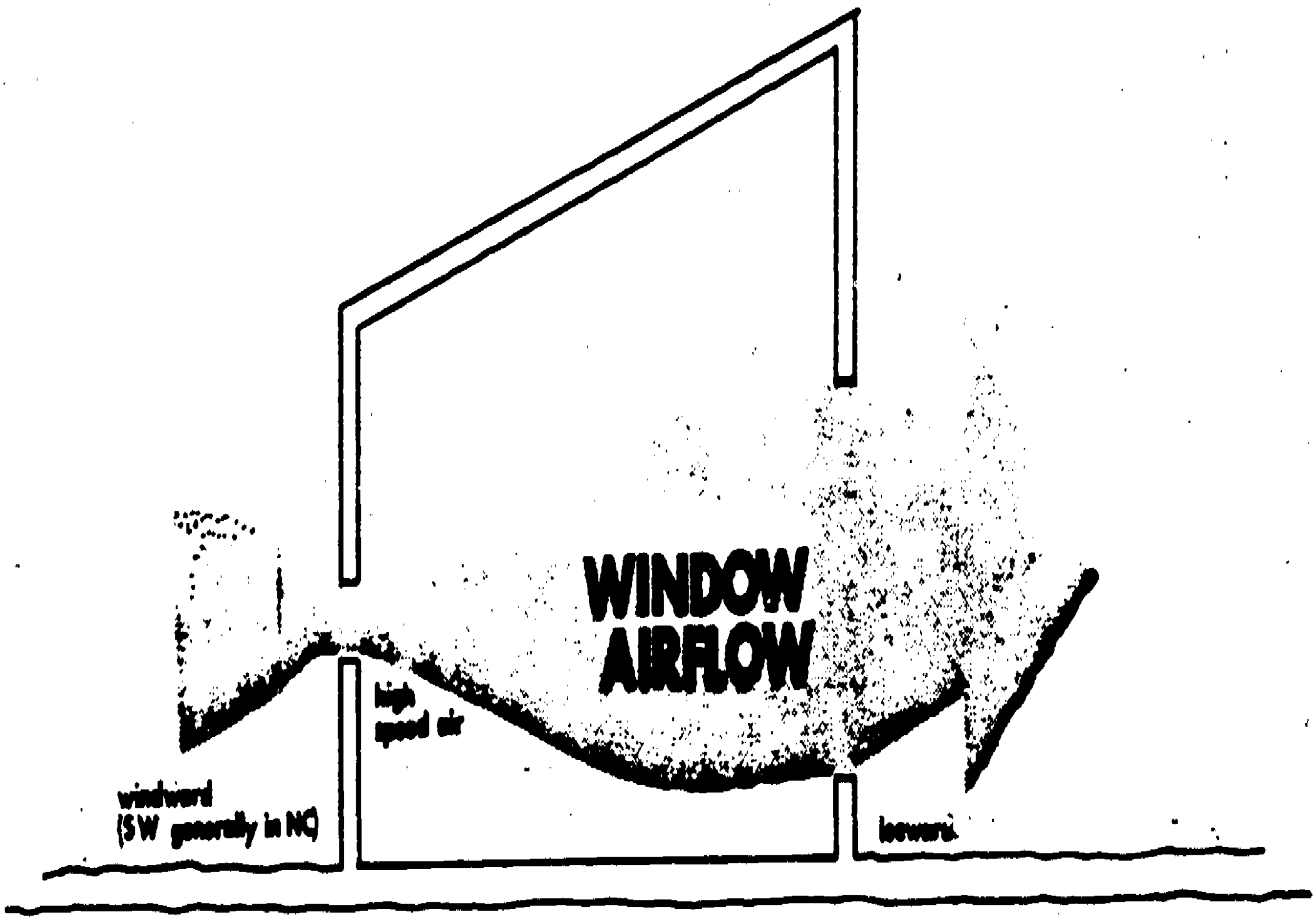
Find the sun's location at 2 p.m., February 21st.

1. Find II (i.e., second month) on left side.
2. Follow horizontal line to intersection with the vertical line with 2 on top (for 2 p.m.).
3. From that intersection, follow a radius down to read 38°. At this time the sun is located at 38°west of south or 218°.
4. Go back to the intersection founa in step 2 and follow along a ring line toward the N-S axis. Read the solar altitude at the intersection of that ring and the N-S axis (35°).
5. The sun's position is 35° altitude at 38° west of south.

CLEAR DAY SOLAR HEAT GAIN THROUGH VERTICAL DOUBLE GLASS FOR 36°N LATITUDE

DAILY HEAT GAIN BTU/SQ. FT.

Date	N	E	S	W
Jan. 21	121	500	1484	500
Apr. 21	281	1003	763	1003
Jul. 21	394	1026	533	1026
Oct. 21	165	681	1380	681



67

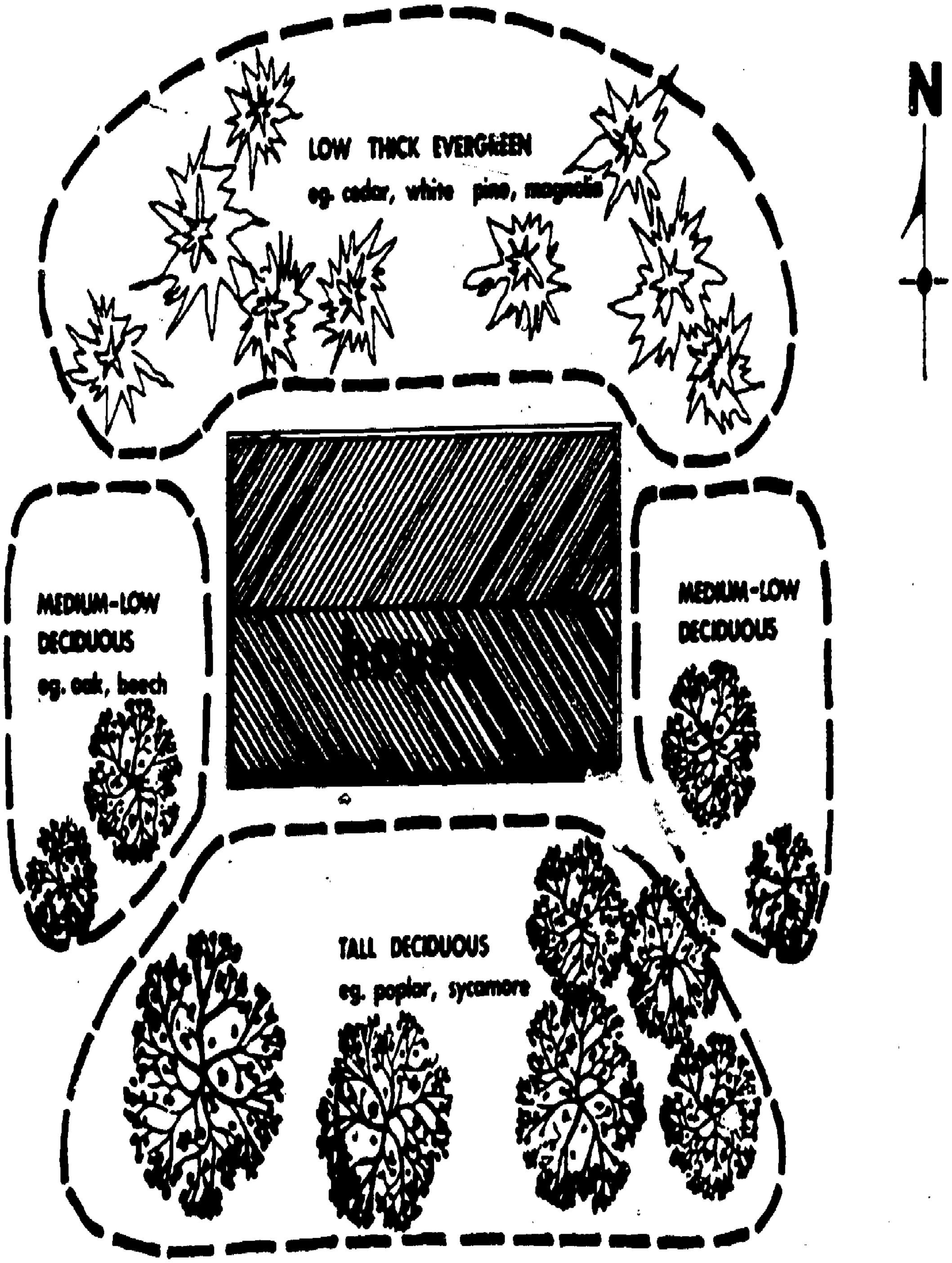
49

HANDOUT #6

50

DESIGNING WINDOWS FOR MAXIMUM VENTILATION

l for: The North Carolina Department of Community Colleges by: integrated energy systems Chapel Hill North Carolina 27514



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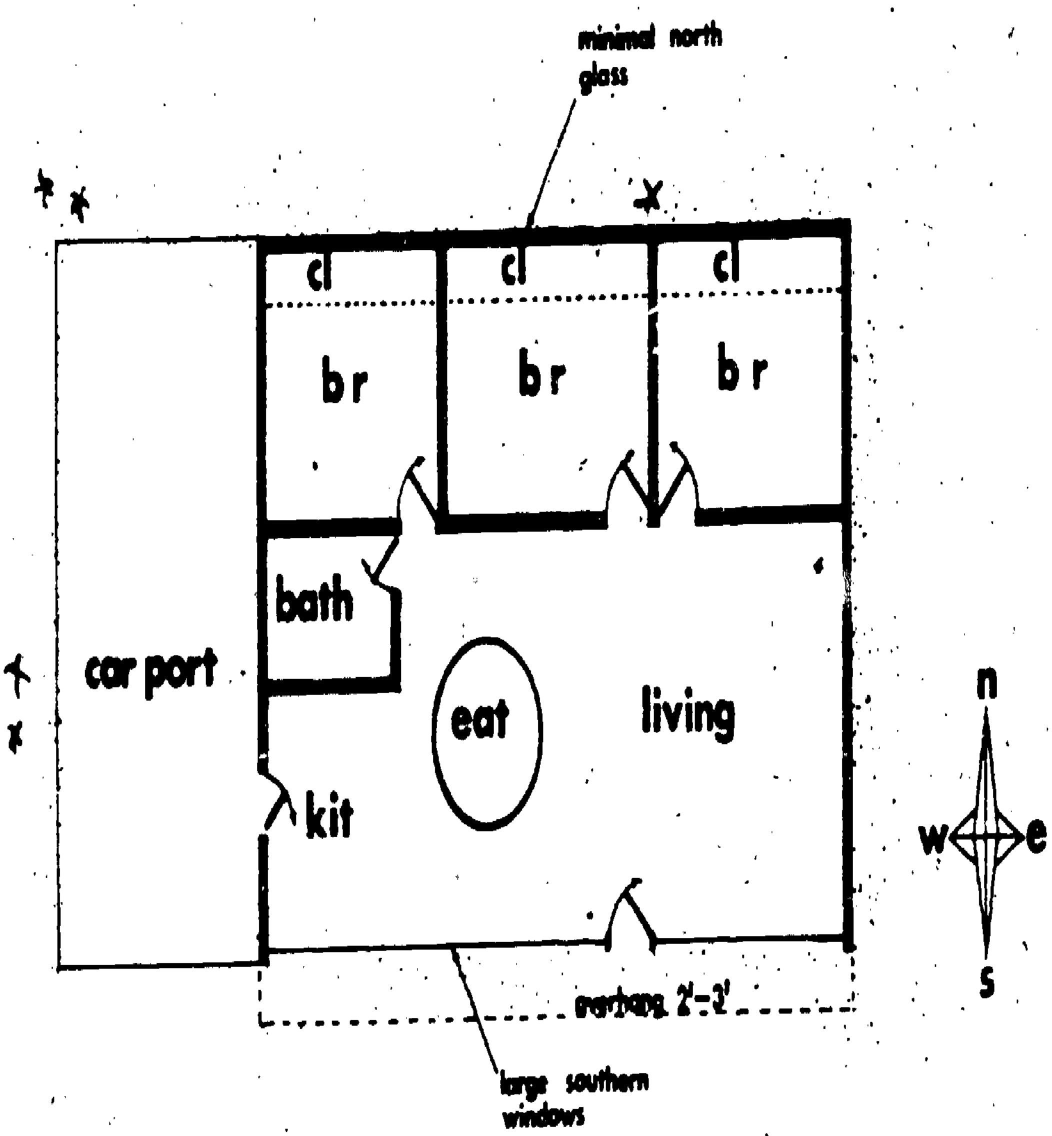
HANDOUT #7

TREE LOCATING FOR ENERGY CONSERVATION

Developed for: The North Carolina Department of Community Colleges by: integrated energy systems Chapel Hill North Carolina 27514



SOLAR ORIENTED INTERIOR LAYOUT

designed for: The North Carolina Department of Community Colleges by: integrated energy systems Chapel Hill North Carolina 27514

HANDOUT #8

SLIDE DESCRIPTIONS*

2 1. Solar movement. In winter, the sun is low in south; in summer it rises north of east, sets north of west and travels high in southern sky.

2 2. Solar movement schematic. Low winter sun penetrates deep into house. Overhang on south side shades glass from summer sun.

2 3. Passive home utilizes extensive south glass and leaves deciduous trees in place. (Builder: John Kernodle, Chapel Hill).

2 4. Passive schematic. Winter sun enters through south glass. Heat is stored in thermal mass of floor (e.g., concrete) or other storage (e.g., water column).

2 5. Exterior insulation and berm wall. Masonry walls provide thermal storage if insulation is applied to outside. Berms reduce heat loss/ gain. (Builder: John Kernodle).

2 6. Insulation on outside of block wall. Styrofoam inset between siding nailers. (Builder: John Kernodle).

2 7. Berm wall. Insulation. Water proof, drainage, and insulation held in place by earth. (Builder: John Kernodle).

2 8. This house has a concrete floor poured over a beefed up frame floor. The concrete provides thermal mass for good passive solar performance.

2 9. A completed built-in greenhouse. Glass panels on top are windows, not solar collectors.

2 10. Interior of greenhouse.

2 11. Few windows on west. Extensive east and west glass is undesirable. It picks up very little winter sun but much summer sun. West glass is worse since heat gain corresponds with hot part of day. (Builder: Fitch Creations, Carrboro).

2 12. Notice extensive south facing double glass with an overhang to provide shading in summer.

2 13. This house has a small window on the west wall adding interest but little A/C load.

2 14. A slightly larger overhang would have shaded these south windows in the summer. Note the ladder which has punctured the sheathing. This will increase infiltration.

2 15. Detail of vents on greenhouse wall. Note slab floor. The north half of the house is over a crawl space.

*See page 3 for information on obtaining slides.

2 16. Natural landscaping is attractive and saves air conditioning costs. In addition, native trees should be left since they will grow best. This house is in the Fearrington Development by Fitch Creations. Energy efficiency is one of their major selling points.

2 17. Vestibule entry provides air lock reducing infiltration. (Builder: John Kernodle).

2 18. Passive home with high R sheathing. Clerestory windows provide light to north side, vestibule entry, little east glass. (Builder: John Kernodle).

2 19. Properly located skylights can provide natural lighting at a lower net cost than electrical lighting. Where possible, try to hide the skylight from the summer sun.

2 20. This glass provides a good view and natural lighting.

2 21. Passive solar spec home by Solomon & Reuben. This one features south glass, skylights and prefab trusses.

2 22. This home steps down a south slope, with large south facing clerestory windows. Notice the native tree left near the porch.

2 23. Custom passive home by Solomon & Reuben. This home won a statewide NCHBA design competition.

2 24. This passive home by Designworks and Space Builders will utilize a greenhouse on a concrete slab on the south side. It also features 2 x 6 walls with RAPCO foam.

2 25. A similar house which has south facing clerestory windows in addition to the greenhouse.

OTHER REFERENCES AND RESOURCES

1. The Builders Guide to Energy Conservation, No. 130.03. Washington, DC: National Association of Home Builders, 1974.

   A very good 63 page booklet covering design, situating on site, HVAC, mass, shading, etc.
   Available for $3.50 from NAHB, 15th and M. Streets, NW, Washington, DC 20005.

2. Alabama Forestry Commission. Value of Tree Shade to Homeowners, AFC No. 2450. Montgomery, AL: Alabama Forestry Commission.

   Available free from Alabama Forestry Commission, 513 Madison Ave., Montgomery, AL 36104.

3. Guide to Constructing an Energy Efficient Home, No. 5-BL-8003. Toledo, Ohio: Owens-Corning Fiberglas.

   Good construction details; few new ideas.
   Available for $1.50 from Owens-Corning Fiberglas, Fiberglas Tower, Toledo, OH 43659.

5. Blunden, Giles and Lucy Davis. Your Next Home. Carrboro, NC: By the Authors, 1978.

   Very good pamphlet discussing passive concepts with calculations on winter heat gain and loss through south glass.
   Available for 50¢ from Giles Blunden and Lucy Davis, P.O. Box 561, Carrboro, NC 27510.

6. U.S. Dept. of Agriculture. Protecting Shade Trees During Home Construction, Home and Garden Bulletin No. 104. Washington, DC: U.S. Government Printing Office, 1975.

   Available for 35¢ from Superintendent of Documents, Government Printing Office, Washington, DC 20402. Request Stock No. 001-000-01309-2.

7. Passive Design Ideas for the Energy Conscious Architect. Rockville, MD: National Solar Heating and Cooling Information Center, August, 1978.

   Available from National Solar Heating and Cooling Information Center, P.O. Box 1607, Rockville, MD 20850.

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SECTION 3

Insulation, Weather-Stripping, Vapor Barriers

SECTION 3. INSULATION, WEATHER-STRIPPING, VAPOR BARRIERS

OBJECTIVE

After presentation of the material in this section, the builder should:

1. understand the pros and cons of various types of insulation, their applicability, and relative costs;
2. recognize the value of good workmanship as it relates to energy use;
3. know where to caulk and weather-strip; and
4. know why vapor barriers are needed and where to place them.

Workmanship/Infiltration

The single most important and cost-effective feature of an energy efficient home is air tightness. Infiltration of cold air in winter can account for 25-50% of the total heat load. Air leaks into and out of a house through thousands of small cracks and holes. Each of these looks insignificant, but their sum effect can be devastating. These cracks and holes should be minimized during construction by careful cutting and attaching of siding, sheetrock, flooring, molding, etc.

Careful workmanship, caulking and/or weather-stripping should be applied at the following places:

- around window & door trim where it meets the siding
- between window & door trim and sheetrock on inside
- around all moving parts in windows and doors
- cutting sheetrock around electrical boxes
- at the bottom of siding
- around plumbing and electrical penetrations
- caulk under sill plate
- seal joints in ducts
- seal around chimneys, flue and drain pipes as they pass through ceiling
- cut appropriate size hole and caulk around floor registers.

Note that a very good way to seal small cracks is with sprayed foam insulation which comes in small containers. Other means to reduce infiltration are:

- use foil-backed insulation
- install storm doors and windows
- build vestibule, air lock entry
- use poly vapor barrier
- use spray-in or rigid foam insulation
- install bathroom and range vents with closeable dampers
- install glass doors or damper in fireplace
- provide outside air for fireplace combustion

Vapor Barriers

Most vapor problems occur in winter when moisture in inside air condenses on cold surfaces. The condensation is at least a nuisance, and can cause paint to peel and wood to rot. There are three solutions to the problem. They are:

1. maintain surfaces which will be contacted by moist air at a temperature above the dew point;
2. avoid introduction of moisture into the air;
3. provide adequate ventilation to keep humidity low.

A typical family of four people produces 20-25 lbs. of water per day. About half of that comes from the bodies, the remainder from cooking, washing, etc. Thus, it is not really practical to avoid introducing moisture into the house. Since ventilation air must be heated, it is desirable to minimize the amount of outside air introduced into the house.

In fact, most houses, even well-built ones, leak enough air to maintain adequate oxygen levels. Thus, the third solution is not desirable either.

The best means to prevent condensation is by prohibiting contact of warm, moist air with cold surfaces. This is achieved by impervious vapor barriers and good insulation. The insulation (and double glazing) keeps inside surface temperatures above the dew point temperature. A vapor barrier keeps the moisture from migrating through the wall. If moisture is allowed to penetrate a wall, it will eventually reach a cold surface where it may condense. This usually happens inside the wall where it is difficult to detect.

Polyethylene film (6 mil minimum) is a good barrier. It should be applied over the inside of the studs before putting in sheetrock.

Plain kraft paper backing is no longer considered an adequate barrier. There are, however, other acceptable alternatives. One is foil-backed sheetrock. The foil is an excellent barrier, but the integrity is impaired by the cracks at the joints. A second option is the use of foam products (rigid or foamed-in-place). These provide good vapor barriers although there is some discussion above whether poly film or foil is needed in addition. Code officials feel additional vapor barriers are needed with spray foam walls; industry spokesmen argue against them. There is not adequate data at present to evaluate this product.

There is also some discussion about double vapor barriers, e.g., poly on inside and foam board on outside. There is concern that condensation will occur on the inside surface of the exterior sheathing. This is not likely

to occur for two reasons: 1) the interior barrier will, if properly applied, stop most moisture; 2) even at the inside surface of the exterior sheathing, an R of 5 to 9 still separates it from outside temperatures. Thus, at temperatures of 10^{o} outside and 70^{o} inside, this surface would be around 60^{o} - over the dew point temperature.

Adequate Ventilation

Adequate attic and crawlspace ventilation is essential. With good ceiling and floor insulation, temperatures in the attic and crawlspace should be near outside temperature. These vents should not be blocked in winter.

Insulation

Pages for reproduction as handouts to the class are included in this section. They contain an outline of the requirements of the new energy sections of the N.C. Building Code and examples of insulation combinations that will meet the code. Also included are descriptions of the five major insulation types, their costs, flammability, advantages, and disadvantages. Some of this information is excerpted from Reference #11.

This section should be preceded by a short lecture on R-values.

ACTIVITIES

1. Show samples of each insulation type. Allow students to feel samples.
2. Ask insulation contractors or sales reps to show films or demonstrate products. This would be especially useful for new products like foam-in-place insulation or poly beads.
3. Encourage a discussion about observed condensation problems. Most of the concerns about vapor are theoretical. Few people have actually seen the problem.

PAGE 67 "COMMONLY USED INSULATION R-VALUES"
REMOVED DUE TO COPYRIGHT RESTRICTIONS.

PAGES 69-74 REMOVED DUE TO COPYRIGHT RESTRICTIONS.

NC BUILDING CODE

RESIDENTIAL ENERGY REQUIREMENTS

GENERAL

1. Good Workmanship
   - -insulate behind pipes and outlets
   - -no voids in stud cavity
2. Vapor Barrier
   - -poly film, or
   - -foil back sheetrock, or
   - -faced batt, facing toward interior
   - -no holes

MINIMUM R-VALUES

1. Flat Roof
   - -exposed beam, R=11
   - -with ceiling cavity, R=19
2. Ceilings, R=19
3. Wall, R=11
4. Floor
   - -frame, R=11
   - -slab, R=3.75, 24" perimeter insulation
5. Windows and Doors
   - -less than 20% of wall glass, single pane
   - -20% or more of exterior wall, double pane or storm windows, and storm doors

VENTILATION

1. No blown insulation if roof slope is less than 2.5/12 or less than 30" headroom.
2. If soffit vents, baffle required to hold back insulation.

WEATHER-STRIPPING

1. All windows and doors (incl. garage) require treatment.
2. Non-hardening sealant used for caulking door and window frames.

FOAM PLASTIC INSULATION

1. If flame spread 75 or less, okay in
   - masonry wall cavity
   - room side of walls and ceilings if covered with 15 min rated material (e.g., 1/2 gyp board)
2. Okay as roof covering if part of Class A, B, or C roof.

INSPECTION AND PERMITS

1. R value and number of bags must be shown on plans if loose insulation used.
2. Insulation contractor must post certification card.
3. Insulation contractor must have local license.
4. Energy inspection after plumbing, heating, electrical rough-in.
5. Insulation certification required for hook-up of permanent electrical service.

NC BUILDING CODE

COMMERCIAL ENERGY REQUIREMENTS

GENERAL

1. Applicability

   -any heated or cooled non-residential building

   -additions to existing buildings

   -over 15,000 sq. ft., Performance Criteria

   -under 15,000 sq. ft., Prescriptive Criteria

2. Unusual Definitions

   -building envelope--all walls, floor, roof

   -coefficient of heat transmission (U)--inverse of the R-value (i.e., U=1/R)

   -glass area--includes sash

   -roof area--total interior surface

   -floor area--measured from outside of exterior walls

3. Thermal Zone - Orange County, Zone II

4. Infiltration and Ventilation

   -weather-stripping and gaskets required

   -max ventilation = 1/3 ASHRAE Std 62-73

5. HVAC

   -simultaneous heating and cooling strongly discouraged; if used sequence heat and cooling, restrict A/C temperature to max usable, installed capacity not to exceed 110% of calculated

   -indoor design temperature, 68° winter, 78° summer, no heating or cooling in-between

6. Lighting

-max allowable 3 watt/gross sq. ft.

-separate switches for areas over 200 sq. ft.

-outdoor lighting not over 2% of interior load

7. Hot Water

-storage water heaters and piping must conform with ASHRAE 90-75

-shower flow less than ^ pm

-in rest rooms limit hot water flow to less than 0.5 gpm, temperature to less than 110°, and limit delivery to max 0.25 gal per activation

PRESCRIPTIVE CRITERIA (<15,000 sq. ft.)

1. Can substitute R value from wall to floor to ceiling to achieve acceptable overall U value.
2. The gross area of exterior walls shall have a combined thermal resistance value (R) not less than the values listed in the following table.

WALL WEIGHT lb./sq. ft.	MINIMUM R VALUE 3 Stories and Under	Over 3 Stories
0-15	2.99	2.51
16-40	2.92	2.43
41-80	2.86	2.36
81-120	2.79	2.29
121+	2.77	2.27

3. Roof, do not include ceiling if building has ceiling air plenum.

ROOF WEIGHT lb./sq. ft.	MINIMUM R VALUE
0-10	10.2
11-50	9.5
51+	8.8

4. Floor over unconditioned space must have minimum R=7.1.

5. Slab-on-grade, minimum R=3.75 around perimeter 24" down or under slab.

PERFORMANCE CRITERIA (>15,000 sq. ft.)

1. Outdoor design temperature 15° winter; 94°DB, 78°WB summer.

2. Maximum allowable simultaneous load shown on the following table.

MAXIMUM ALLOWABLE SIMULTANEOUS LOAD

OCCUPANCY		ALLOTMENT	
		Watts/GSF	BTUH/GSF
A	(Residential)	8.5*	29*
B-1	(Business)	7.6	26
B-2	(Business)	6.8	23
C	(Schools)	8.0	27
D	(Institutional)	8.3	28
E	(Assembly)	5.7	19
G	(Industrial)	6.4	22

*This figure is intended for environmental systems only. All other usage is excluded.

Heating, cooling, hot water, humidification are included.

SERVICE WATER HEATING (brief summary)

1. Insulation

   -at least R=3 on all hot water storage tanks

   -R=3-6 required on pipes

2. Space heating boilers may not be used for service hot water only.

3. Temperature Controls

   -provide full range adjustment

   -provide separate switch or valve

   -max swimming pool temperature, 80°

   -no pool heating if outside temperature less than 60°

   -provide easy shut off for circulating pump

EXAMPLES OF INSULATION COMBINATIONS ACCEPTABLE IN NC

CEILINGS WITH INSULATION (i.e., unheated attic), MINIMUM R=19

1. Vapor barrier with blown fill
   - -fiberglass, 6", or
   - -cellulose, 5", or
   - -polystyrene beads, 4.5"
2. Batts with integral vapor barrier, 6"
3. Combination batt and blown

ROOF (CATHEDRAL CEILING)

1. Rigid insulation, minimum R=11
   - -rigid fiberglass, 6", or
   - -polystyrene T&G, 4.4", or
   - -polyisocyanurate, 2", or
   - -styrofoam, 3.5"
2. Batts between joists, minimum R=19
   - -batt, 3 1/2", and polystyrene, 2", or
   - -batt, 3 1/2", and polyisocyanurate, 1", or
   - -batt, 6"

FRAME WALLS, MINIMUM R=11

1. Fiberglass batt with vapor barrier, 3 1/2"
2. Fiberglass batt with vapor barrier, 3 1/2", and insulating sheathing, 3/4" (e.g., styrofoam), R=15
3. UF foam with vapor barrier (e.g., Rapco), R=16

MASONRY WALL, MINIMUM R=11

1. Block (density - 60) filled with UF foam, R=11.
2. Block filled with any loose fill, must have additional insulation.
3. Brick cavity wall, cavity must be filled with R=9

   -UF foam, 2" or

   -rigid polystyrene, 2", or

   -rigid polyisocyanurate, 1.2", or

   -vermiculite, 3.75", or

   -polystyrene beads, 2.25", or

   -styrofoam, 1.7"

FLOORS

1. Frame, fiberglass batts, 3 1/2".
2. Perimeter of slab rigid board 24" below grade to footing or under exterior 24" of slab, R=3.75, moisture barrier.

   -polystyrene, 3/4", or

   -polyisocyanurate, 1/2", or

   -styrofoam, 5/8"

PAGES 83-84 "INSULATION COSTS" REMOVED DUE TO COPYRIGHT RESTRICTIONS

A COMPARISON OF INSULATION IN NEW CONSTRUCTION

Type	Application	R*/Inch	Est. Matl. ¢/R/Sq.Ft.	Est. Labor ¢/Sq.Ft.	Total Est. ¢/R/Sq.Ft.	Comments
Fiberglass batt (6")	anywhere inside	3.11	1.29	0.45	[illegible]	Req. poly vapor barrier, old standby, may not cover rafters.
Blown fiberglass	ceiling	2.15	N/A	N/A	1.42	Covers rafters, may be uneven, req. vapor bar.
UF foam	wall, ceiling	4.50	N/A	N/A	2.22	Req. poly vapor barrier or foil sheetrock, scheduling problems.
Polystyrene (1") bead board	wall, ceiling foundation	4.33	2.66	2.22	4.88	Very common for sheathing, questions re: dbl. vapor barrier.
Polyisocyanurate (1") (eg. Celotex Thermax)	wall, ceiling foundation	8.00	3.88	2.22	6.10	Not widely available, rated R value may be too high.
Cellulose	ceiling, wall	3.67	N/A	N/A	1.00	Questions re: fire & vermin resistance, few standards.
Vermiculite	masonry wall	2.40	3.96	1.42	5.38	
Polystyrene beads	wall, foundation	4.00	0.71	0.18	0.89	New product, little data
Styrofoam T&G (3/4")	wall, foundation	5.41	5.91	2.22	8.13	Question flammability.

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HANDOUT #16

*Reported R values vary widely

Quantity prices: Fall, 1979

SLIDE DESCRIPTIONS*

Workmanship/Infiltration

3 1. Space at bottom of short insulation piece - stress good workmanship.

3 2. Getting insulation around electrical box - actual measurements in townhouses in N.J. showed 10% of total heat loss from penetrations.

3 3. Getting insulation under electrical wires - a better way is to run wires along sill plate as in Arkansas house.

3 4. Getting insulation under pipes.

3 5. Stuffing insulation around chimney - requires care, spray foam may be better here to seal small cracks.

3 6. Stuffing insulation around window.

3 7. Foaming plumbing penetrations - very good use for small foam dispensers, faster and better than stuffing fiberglass.

3 8. Stuffing insulation around window & block - fill large holes with fiberglass, fill small holes with foam.

3 9. Stuffing insulation around door.

3 10. Insulating attic door - very difficult but important. Good design is to have access to attic from outside through carport or garage.

3 11. Be sure to tape duct joints before insulating, then also tape insulation joints. Leaky ducts can account for 15% of heating or cooling load.

3 12. In addition to insulation use, weather-stripping, caulking, proper materials and careful workmanship.

3 13. Installing weather-stripping on door - a most cost-effective measure.

3 14. Outside doors are major source of infiltration; they should be well weather-stripped and protected from wind. Weather-stripping on door must be well adjusted. If it does not contact the door it does little good.

Caulking

3 15. Caulking, like weatherstripping is essential. Crack under sill showing need for caulking.

*See page 3 for information on obtaining slides.

3 16. Caulking around window.

3 17. Caulking storm window.

3 18. Caulking under sill plate. (Builder: Fitch).

3 19. Caulk under sill.

3 20. Caulking between window trim and siding.

3 21. Caulk around floor registers - first cut the hole to the exact size, then caulk or foam joint between duct and flooring.

Materials

3 22. Window with plastic flashing can be purchased and provides good seal.

3 23. Storm windows or double glaze is mandatory. Single glazed window loses 20 times as much heat as insulated wall. Extra glazing cuts that in half.

3 24. Storm door - good energy saver but not yet cost-effective in our climate. Highly visible for consumer, good for sales.

3 25. Attractive, custom storm door.

3 26. Good cut on sheetrock around electric box. (Builder: Trollinger).

3 27. Good cut on siding against window sash.

3 28. Vapor barrier plastic around window - extend plastic over entire wall then carefully cut out openings.

3 29. Crack around newly placed metal door.

Vapor Barrier

3 30. Vapor barriers are needed for moisture and infiltration guard.

3 31. Insulated wall section schematic - polyethylene film not shown, be sure to use it or foil-backed sheetrock.

3 32. Foil-backed insulation provides a good moisture barrier.

3 33. Installing polyethylene vapor barrier.

3 34. Plastic on ground in crawl space - necessary with crawl space plenum. Desirable in normal construction to keep floor insulation dry.

3 35. Peeling paint is caused by poor vapor barrier on the inside.

3 36. Water marks, inside around window caused by poor vapor barrier.

3 37. Removing kraft paper before adding additional insulation - avoid two vapor barriers.

3 38. Cutting vapor barrier before adding insulation to avoid two vapor barriers.

Adequate Ventilation

3 39. Three types of attic vents.

3 40. Vent size requirements. Recommended: 1 sq. ft. to 300 sq. ft. ceiling area with vapor barrier. 1 sq. ft. to 150 sq. ft. ceiling area without vapor barrier.

3 41. Attic ventilation, vapor flow diagram - ventilation above the attic insulation is necessary, both winter and summer. In winter, the open vents let moisture escape. In summer, they let air move through the attic to lessen the build-up of heat. A combination of vents at the eaves, the lowest part of the roof and vents at the top is the best arrangement.

3 42. This is a nice combination flashing and vent.

3 43. Soffit vent is ideal.

3 44. Soffit vent board to keep batts from impeding soffit to gable ventilation. Avon Previtt, Statesboro, uses 2 x 4 on side to provide vent space.

3 45. Gable vent not as good as continuous ridge but some buyers prefer appearance.

3 46. Power ventilators not worthwhile with good attic insulation. Wind turbine type are adequate.

3 47. Crawl space vents are essential to keep insulation dry and intact.

3 48. Crawl space vents.

3 49. Caulking bottom of siding - some dispute about caulking here, may be better to allow exterior to breathe and seal interior.

Insulation - R-Values

3 50. Definition of R - resistance to heat flow, inverse of conductance which has units of BTU per sq. ft. per hour per degree temperature

difference on two sides. R-numbers can be added together. Put in an R-19 batt and a R-11 for a total insulation value of R-30. R-30 batts and R-38 are also available.

3 51. Equivalent R's in insulation, wood, brick. There are many myths about the R-value of wood; in fact, it is about R-1 per inch.

3 52. Comparison of R-values of different insulation.

3 53. How much to install - code requirements are less than economic optimum levels, try for R-19, 19, 30 (wall, floor, ceiling). The thickness of the insulation is not the major factor. We've all been accustomed to talking about "6 inches" of insulation, or "3 inches." But with modern insulating materials, inches alone don't matter very much.

3 54. Measuring batt - 10 inch batt gives R=30.

3 55. Loose insulation is a good, cheap way for a homeowner to add R's.

3 56. Measuring loose insulation - 13-14 inches of loose fiberglass gives R=30.

3 57. Bag label - inspectors will be counting bags to insure R's. Here's how each bag of loose fill insulation should be labeled. This type of label is required by federal specifications for both mineral wool and cellulose. The column on the left lists R numbers. The next tells how many bags are needed to cover 1,000 square feet of attic floor area. The third column gives the minimum thickness you should have after the job has been done. The last column tells the maximum number of square feet one bag will cover.

3 58. Measuring loose cellulose 8-9 inches of cellulose gives R=30.

Insulation Types

3 59. There are many types of insulation available now. Each has a good application.

3 60. Cellulose - Cellulose is made of paper, usually old newspapers, ground up into particles. Cellulose is an organic, vegetable material. All types are chemically treated to resist fire and vermin. Cellulose is divided into Class I and Class II types. Class I is more fire retardant. Before you have cellulose installed in your house, ask the dealer or contractor to test its flammability for you, and obtain testing data from lab reports.

3 61. Checking cellulose in attic.

3 62. Rock wool and fiberglass. Mineral wool is either rock wool or fiberglass. Both are inorganic materials meant to be installed by the do-it-yourselfer or an insulation contractor. Fiberglass is available as batts, blankets, or as loose wool. Mineral wool batts come in 4-foot or 8-foot lengths.

Blankets come in longer rolls which are cut to length as needed. Both are available with or without a vapor barrier on one side. The purpose of the vapor barrier is to inhibit moisture transfer and keep the insulation dry. Performs poorly in moist environment.

3 63. Blown and batt equivalent thicknesses for R-19.

3 64. Blowing fiberglass into masonry wall cavity - some questions about moisture absorption and whether foam or plastic might be better.

3 65. Three types of foam boards: beadboards and styrofoam have about R-4 per inch; urethane (polyisocyanurate) has about R-7 or 8 per inch.

3 66. High R sheathing has very good R value and is a real eye catcher during construction.

3 67. Styrofoam sheathing - very good for this application, will not absorb moisture.

3 68. Styrofoam sheathing under wood siding.

3 69. Weighing foam block. Urea formaldehyde is composed of chemicals. When urea resin, a catalyst, and compressed air are brought together, they react by foaming up much like shaving cream. Urea formaldehyde foam should not be left exposed and is, therefore, used in the walls only. Since this product is actually "manufactured" or mixed on the job site, contractor application is required. One word of caution - this field "mixing" is very delicate and requires an experienced applicator.

3 70. Foaming new wall - foam adheres directly to studs sheathing.

3 71. Screeding foam.

3 72. Rapco between studs - some concern about shrinkage. Remember, just 2% means a 2 inch gap in a stud cavity. More field experience is needed.

3 73. Rapco in wall around pipes - foams fills very well around pipes and wiring.

3 74. Rapco around window - foam fills very well ir small openings.

3 75. Foam around flue pipe - foam is non-combustible but it is best to avoid contact with very hot surfaces.

3 76. Foam between block and brick - fills voids very well; in this application don't have to hurry to complete vapor barrier as in stud wall.

3 77. Foaming brick wall - foam is best way to insulate walls of old house.

3 78. Siding plug after foaming in old house.

3 79. Places to insulate.

3 80. House cut away with insulation - point out all the places to insulate, including slab floors.

3 81. Incomplete blown insulation in ceiling.

3 82. Installing batt in ceiling.

3 83. Batts bulging over rafters provides good seal over low R wood sections.

3 84. Fat batt and regular batt - thicker batts are now available. They are slightly wide to provide bulge over rafters.

3 85. Installing second batt in ceiling - most builders blow additional insulation over first batt which provides a good seal.

3 86. Installing batts around joist bridging - again, stress workmanship.

3 87. Installing batts around recessed light - setback of 3" is required which leaves a substantial hole in insulation, avoid recessed lighting.

3 88. Attic and duct insulation - ideally ducts should be located within the conditioned space, if not, be sure to tape and insulate.

3 89. Installing batts in cathedral ceiling - be sure to leave enough space in roof to install insulation, in this case done with trusses.

3 90. Wall and ceiling insulation. Note vapor barrier on inside.

3 91. Installing batt in wall.

3 92. Styrofoam sheathing in wall.

3 93. Exterior insulation glued to block wall.

3 94. Rigid insulation board and cinder blocks - use insulation in cavity walls.

3 95. Furring basement wall for batts - easier and better to install rigid insulation on outside of wall before back filling.

3 96. Installing batts in basement wall - this is necessary when using crawl space as plenum, superfluous otherwise.

3 97. Insulating basement or crawl space wall - actually face stapling is better since it doesn't compact insulation, but many sheet rockers object.

3 98. Installing floor insulation with chicken wire, a very good way of supporting insulation but time consuming.

3 99. Insulation in floor with string support.

3 100. Insulation in floor with wire support (tiger teeth) probably the best and most used method of support.

3 101. Insulating band joist - heat is transferred by the wood.

3 102. Slab perimeter ion - run insulation up to top of slab and 2 feet under ually all heat lost from slab is at perimeter.

OTHER REFERENCES AND RESOURCES

1. Malloy, J. F. Thermal Insulation. New York: Van Nostrand Reinhold Co., 1969.

   Engineering type text book for very serious reader.

2. Fight Back. RAPCO.

   A 10 minute promotional film which shows burning properties, laboratory use in transparent wall, and field installation. Good introduction.
   Availabe from RAPCO Insulation, Durham, NC (Ph. 596-2127).

3. Blowing Wool Application Manual, No. 5-BW-.757. Toledo, Ohio: Owens-Corning Fiberglas.

   Available from Owens-Corning Fiberglas, Fiberglas Tower, Toledo, OH 43659.

4. Sill Sealer and Prescored Perimeter Insulation, No. 1-BL-6434-B. Toledo, Ohio: Owens Corning Fiberglas.

   One page product description sheet.
   Available from Owens-Corning Fiberglas (address above).

5. Building Insulation Application Manual, No. 5-BL- 55. Toledo, Ohio: Owens-Corning Fiberglas.

   A comprehensive how-to booklet. Good construction details; few new ideas.
   Available from Owens-Corning Fiberglas (address above).

6. Insulation Guide for Homes and Apartments, Raleigh, NC: Carolina Power and Light Company.

   A booklet discussing R-values, where and how to insulate and ventilation.
   Available free in quantities up to 200 from CP&L Customer Service, P.O. Box 1551, Raleigh, NC 27602.

7. Insulation Manual: Homes and Apartments. Rockville, MD: National Association of Home Builders, 1971.

   Fairly technical and somewhat outdated, but contains good information.
   Available for $4 from NAHB, 15th and M. Street, NW, Washington, DC 20005.

8. Urea-Formaldehyde Based Foam Insulation: An Assessment of Their Properties and Performance, NBS TN 946. Washington, DC: Government Printing Office, July, 1977.

   Fairly critical 92 page report on U-F insulation.
   Available for $2.30 from Superintendent of Documents, Government Printing Office, Washington, DC 20402.

9. A Response to NBS Technical Note 946. October, 1977.

Available free from National Association of U-F Insulation Manufacturers, P.O. Box 23478, Jacksonville, FL 32217.

10. "Insulation: The Builders Key to Energy Conservation." Reprint from Professional Builder, II (November, 1973).

Contains discussion of insulation, FAA minimum standards, optimal levels, and quality control.
Available free from Johns-Manville Corporation, Box 5705-RP-V2, Denver, CO 80217.

11. Enforcing Energy Codes: A Workshop for Building Inspectors. Chapel Hill, NC: Integrated Energy Systems.

A 90 page manual describing North Carolina codes, insulation types and costs.
Excerpts included here.
Available for $5.00 from Integrated Energy Systems, 211 N. Columbia St., Chapel Hill, NC 27514.

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SECTION 4

Mechanical Systems And Energy Savers

SECTION 4. MECHANICAL SYSTEMS AND ENERGY SAVERS

OBJECTIVE

After presentation of the material in this section, the builder should

1. know the advantages, problems and economics of heat pumps;
2. be able to give buyers information on solar water heaters;
3. understand the differences between modern, air-tight wood stoves and older units;
4. understand the importance of good fireplace design; and
5. know the applicability of other energy saving devices such as timers, water savers, humidifiers, and power ventilators.

BACKGROUND

Introduction

There are literally hundreds of devices on the market which are purported to be energy savers. It would be impossible to cover them all. Therefore, the discussion is confined to those which are most asked about. Further, only the energy and money savings aspects are considered here. (Handout #26, Section 5 lists and explains some energy conserving equipment).

Heat Pump

Application

- central a/c desired
- forced air heating desired
- no other fuel available or acceptable

Advantages

- clean
- seasonal heating efficiency about twice that of resistance electric
- low heating bills in cool months
- packaged unit for heating & cooling, easy installation

Disadvantages

- outdoor unit and registers may be noisy
- high air volume at relatively low temperature may result in drafts in winter
- use of resistance strips during coldest weather adds to utility peak demand problems
- very high electric bills in coldest months due to use of resistance strips

Economics

- heating cost about 1/2 that of resistance electric, about equal to the cost of delivered heat from oil furnace, slightly more expensive than natural gas
- slightly more expensive in summer than high efficiency a/c unit (Energy Efficiency Ratio (EER) 8.0 versus 10.5 for a high efficiency a/c unit)
- adds about $500 to cost of resistance and central a/c system, pays for itself in about 2 years

Notes

- water to air are available, require large water volumes, e.g., 10-15 gpm with summer surface water, long term performance unknown
- gas or oil backup (instead of resistance electric) is now available
- usual balance point for heat pump is 35-38°, below this some or all resistance strips are operating

Solar Hot Water

Application

- preheat water before it enters regular water heater
- requires good solar exposure, south facing, about 45° tilt, area
- about 7' x 7'

Advantages

- customer appeal, good for sales
- low operating cost
- saves conventional energy

Disadvantages

- lifetime unknown (although there are many units over 40 years old in Florida, Israel, Australia)
- may be aesthetically unacceptable
- new product

Economics

- typical cost for family of four, installed, retail $1600; collects about 200,000 BTU/yr.-sq.ft., which equals $2.23/yr.-sq.ft., or about $7.05/mo. for a 38 sq. ft. system
- tax deduction in NC of 25% of first cost up to $1000 credit
- federal income tax credit is 30% of first $2000, 20% on next $8000, to a maximum of $2200
- for cash flow analysis, assume first cost is $720 (i.e., $1600 minus 55% credit) which adds $6.05 to monthly mortgage payment
- there is an immediate positive cash flow when the state and federal tax credits are considered. (Handout #18).

Wood Stoves

Application

- any home where buyer desires

Advantages

- customer appeal
- attractive appearance
- very cheap heat with owner labor
- efficient - wood stove is 40-50% efficient, compared to conventional fireplace being 0-10%, and a good fireplace being 10-30%
- no masonry required
- units are available to allow viewing of fire

Disadvantages

- requires considerable floor area, 3' separation from non-masonry or non-asbestos materials

  can be messy
- may cause air pollution problems if used on large scale
- installation can be expensive

Economics

- cost of good stove, $500-900
- cost of installed insulated pipe, $14-20 per foot of pipe or $200-400 per installation
- good oak purchased for $60/cord produces heat at 65% the cost of a heat pump

Fireplaces

Application

- when customer desires

Advantages

- proven seller of homes
- can view fire

Disadvantages

- may result in net heat loss if damper and/or doors not used
- often requires brick and foundation work
- low efficiency

Economics

- masonry unit costs $1500 up, will never pay for itself if wood is purchased

Notes

- major deficiencies in conventional units are: 1) draws warm air from house for combustion; 2) draws cold air into the house through cracks; 3) draws warm air out at night after fire is out if damper is still open
- solutions: 1) provide intake for outside air for combustion; 2) provide means to cover fireplace opening even while fire is going
- fireplaces should be placed on interior walls, otherwise they lose heat
- install a jacketed fireplace insert

Timers

Application

- attach to water heater or furnace/ac
- attach to lights

Advantages

- never forgets to set back temperatures at night
- 7-day timers provide for a different sequence on weekends
- greatly reduces standby energy consumption by water heater

Disadvantages

- will not save money on normal heat pump in heating mode because it may cause resistance strips to be used unnecessarily
- plug-in type needs to be reset for blackouts or daylight savings time

Economics

- cost \$25-75 depending on sophistication, e.g., 24 hr. versus 7-day device
- 5^{o} night set back gives 7-12% savings
- 10^{o} night se back gives 10-16% savings, i.e., about 1 1/2% per degree of set back
- usual payback less than 2 years

Water Savers

Application

- low flush toilets
- flow restricting shower and faucet heads
- foot activated faucets
- timed delivery faucets
- washers, dishwashers

Advantages

- reduces water consumption/costs
- eases septic or sewer system load
- saves hot water
- good sales device

Disadvantages

- none

Economics

- shower head \$5-15 added cost, payback 2 years
- toilet, \$0-50 added cost, payback 2-5 years

Notes

- single handle faucets can waste hot water because consumer may simply turn on water without noticing that faucet is set on "hot water."

Humidifier

Application

- when low winter humidity causes problems for people, plants, or furniture

Advantages

- improves comfort
- may allow reduced thermostat setting

Disadvantages

- consumes energy
- may cool delivery air temperature
- low visibility for sales

Economics

- some studies indicate that energy consumption in evaporation exceeds savings due to lower thermostat setting; no definitive data available

Power Ventilator

Application

- to remove heat and moisture from attic space

Advantages

- reduces a/c demand
- may prolong life of roof by cooling
- makes attic more usable
- high visibility for sales

Disadvantages

- consumes energy
- may be noisy
- may increase infiltration into house
- may cause roof leaks if not properly installed
- may be unsightly

Economics

- Army & NBS studies show that in a well-insulated attic, energy consumed by fan may exceed cooling energy saved when compared to non-powered ventilators. (Handout #19).

Notes

- wind-powered turbines preferable to powered ventilators

Miscellaneous Energy Savers

- steel straps for corners in place of plywood, allows use of insulating sheathing on corners
- automatic flue dampers on gas appliances reduce heat loss up stack; recent AGA approval; appears to have 2-4 year payback
- some new gas appliances are available with electronic pilots; these pilots should show a 1-3 year payback
- use energy efficient appliances
- heat exchangers are available to recover wasted condenser heat in summer; since they operate only when a/c is on (i.e., about 1000 hr/yr), they will have a long payback
- in-line demand type water heaters can save up to 33% over a normal unit by eliminating standby losses

- light dimmer switches save energy on incandescent bulbs
- metal/foam core doors with refrigerator type insulation are good <u>if</u> they are hung properly
- insulate hot water pipes

ACTIVITIES

1. Ask a supplier of woodstoves to speak and show his/her products.
2. Show the students sample timers, water savers (such as shower restricters or toilet dams).
3. Go through local climatological data for the area to determine how many hours a heat pump will be operating below its balance point. See enclosed LCD for January 1978, RDU Airport. (Handout #17). Note number of times temperature reading was below 36°. Each of these represents 3 hours. Students may be surprised by large number of hours during which resistance heat must operate. (429 hours, 58% of time in this example.)
4. Examine and discuss list of "Energy Conserving Equipment" (Handout #26, Section 5).
5. Ask the students to add to the list of energy saving devices. Ask about costs, acceptance, problems, sales, etc.

JANUARY 1978
RALEIGH, NORTH CAROLINA
NAT WEATHER SERVICE FCST OFC
RALEIGH DURHAM AIRPORT

Local Climatological Data*

MONTHLY SUMMARY

JANUARY 1978 RALEIGH, NORTH CAROLINA

LATITUDE 35° 52' N LONGITUDE 78° 47' W ELEVATION (GROUND) 434 FT. STANDARD TIME USED: EASTERN WBAN #13722

Date	Temperature °F: Maximum	Minimum	Average	Departure from normal	Average dew point	Degree days base 65°: Heating (season begins with Jul.)	Cooling (season begins with Jan.)	Weather types on dates of occurrence (1 Fog, 2 Heavy fog, 3 Thunderstorm, 4 Ice pellets, 5 Hail, 6 Glaze, 7 Duststorm, 8 Smoke, haze, 9 Blowing snow)	Snow, ice pellets or ice on ground at 07AM in.	Precipitation: Water equivalent in.	Snow, ice pellets in.	Avg. station pressure in. elev. 441 feet m.s.l.	Wind: Resultant dir.	Resultant speed m.p.h.	Average speed m.p.h.	Fastest mile: Speed m.p.h.	Direction	Sunshine: Minutes	Percent of possible	Sky cover tenths: Sunrise to sunset	Midnight to midnight	Date
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	43	37	40	0	39	25	0	1	0	T	0	29.54	22	2.2	5.3	12	23	0	0	10	9	1
2	44	25	35	-5	24	30	0	1	0	0	0	29.55	29	7.9	8.5	14	30	541	92	5	4	2
3	42	22	32	-8	14	33	0		0	0	0	29.78	29	4.7	8.6	15	30	566	100	0	0	3
4	48	18	33	-7	15	32	0		0	0	0	30.00	10	.6	5.0	8	22	503	85	2	2	4
5	56	26	41	1	23	24	0		0	0	0	29.88	20	4.2	4.9	8	21	261	44	7	8	5
6	50	43	47	7	46	18	0	2	0	.59	0	29.64	17	1.7	5.0	12	13	0	0	10	9	6
7	47	40	44	4	43	21	0	2	0	T	0	29.72	03	4.5	5.6	9	07	0	0	10	10	7
8	68	43	56*	16	54	9	0	1	0	1.23	0	29.39	15	12.0	13.1	23	17	0	0	10	10	8
9	63	18	41	1	21	24	0	1 4	0	.19	T	29.19	29	15.9	17.0	28	29	437	74	3	4	9
10	29	11	20*	-20	-1	45	0		0	0	0	29.71	28	12.1	12.2	17	25	594	100	0	0	10
11	36	10*	23	-17	3	42	0		0	0	0	29.91	29	4.9	6.9	10	34	595	100	2	1	11
12	45	13	29	-11	12	36	0	1 4 6	0	.07	T	29.85	11	2.3	2.7	6	05	500	84	6	5	12
13	35	31	33	-7	33	32	0	1 6	T	1.36	0	29.38	01	8.2	9.1	14	01	0	0	10	10	13
14	42	34	38	-2	34	27	0	1 6 8	0	T	T	29.17	28	8.3	7.3	12	29	282	47	10	10	14
15	39	25	32	-8	23	33	0		0	0	0	29.51	29	11.7	12.4	17	26	522	87	6	5	15
16	42	17	30	-11	17	35	0		0	0	0	29.88	13	1.1	5.0	6	19	462	80	6	6	16
17	54	34	44	3	35	21	0	1	0	.83	0	29.55	07	2.4	7.6	17	24	0	0	10	10	17
18	51	30	41	0	36	24	0	1	0	0	0	29.80	29	7.3	9.4	15	30	516	85	3	5	18
19	39	31	33	-8	30	32	0	1 6	0	1.23	0	29.83	05	7.3	7.9	13	04	19	3	10	10	19
20	37	32	35	-6	34	30	0	1 6	T	.29	0	29.28	31	4.4	7.8	10	23	0	0	10	9	20
21	39	28	34	-7	27	31	0	1	0	0	0	29.67	28	9.5	9.8	15	27	569	97	2	4	21
22	36	24	30	-11	23	35	0		0	T	T	29.93	34	4.1	5.0	9	36	132	22	10	9	22
23	44	19	33	-8	24	32	0	1 8	0	0	0	29.98	02	2.6	3.2	8	03	566	96	2	1	23
24	51	24	38	-3	27	27	0		0	T	0	29.79	11	2.7	4.5	8	15	376	61	9	7	24
25	66	38	53	12	53	12	0	1 3	0	1.16	0	29.15	18	8.7	14.4	29	17	0	0	10	10	25
26	66*	25	47	8	28	18	0	1 3	0	.28	0	28.98	23	22.7	23.9	32	26	607	99	3	4	26
27	43	24	34	-7	14	31	0		0	0	0	29.42	23	14.5	14.8	23	25	618	100	0	0	27
28	37	20	29	-12	13	38	0		0	0	0	29.51	28	12.5	13.1	20	28	560	90	2	1	28
29	34	12	23	-16	7	42	0		0	0	0	29.64	30	9.8	10.6	16	30	621	100	1	2	29
30	37	13	25	-16	9	40	0		0	0	0	29.78	29	8.5	7.2	12	33	608	98	3	2	30
31	41	14	28	-13	15	37	0		0	0	0	29.76	31	5.3	5.8	20	30	475	78	6	3	31

Maximum	Minimum	Average	Departure	Avg. dew point	Heating	Cooling
SUM	SUM				TOTAL	TOTAL
1406	781				914	0
AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.
45.4	25.2	35.3	-5.2	25	154	0
					SEASON TO DATE	
					TOTAL	TOTAL
					2380	0
					DEP.	DEP.
					234	0

NUMBER OF DAYS			
MAXIMUM TEMP.		MINIMUM TEMP.	
≥ 90°	≤ 32°	≤ 32°	≤ 0°
0	1	24	0

NUMBER OF DAYS	
PRECIPITATION ≥ .01 INCH	10
SNOW, ICE PELLETS ≥ 1.0 INCH	0
THUNDERSTORMS	2
HEAVY FOG	2
CLEAR 13	PARTLY CLOUDY 5 CLOUDY 13

Precipitation TOTAL	Snow TOTAL	FOR THE MONTH: Pressure	Resultant dir.	Resultant speed	Avg. speed	Fastest speed	Fastest dir.	Sunshine TOTAL	%	Sky cover SUM	SUM
7.03	T	29.60	28	3.8	9.8	32	26	11012	FOR MONTH	180	170
DEP.						DATE: 26		POSSIBLE		AVG.	AVG.
3.81								10884	59	5.8	5.5

GREATEST IN 24 HOURS AND DATES				GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
PRECIPITATION		SNOW, ICE PELLETS			
1.52	19-20	T	22+	T	20+

* EXTREME FOR THE MONTH LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM.
DATA IN COLS. 6 AND 12 15 ARE BASED ON 8 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

SUMMARY BY HOURS

Hour local time	AVERAGES: Sky cover tenths	Station pressure in.	Temperature: Air °F	Wet bulb °F	Dew pt. °F	Relative humidity %	Wind speed m.p.h.	Resultant wind: Direction	Speed m.p.h.
01	5	29.58	32	31	28	79	7.5	27	3.2
04	5	29.59	30	28	24	81	7.8	29	3.5
07	6	29.61	28	27	23	82	7.2	29	2.6
10	5	29.66	35	32	26	71	9.6	28	4.4
13	5	29.60	40	35	25	58	11.1	28	5.6
16	6	29.57	42	38	26	57	11.1	27	6.2
19	5	29.60	36	33	25	67	7.9	28	2.4
22	5	29.61	34	31	25	72	7.8	25	2.8

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noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA SERVICE

Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 02/23/78 475

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HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

Date	A.M. 1	2	3	4	5	6	7	8	9	10	11	12	P.M. 1	2	3	4	5	6	7	8	9	10	11	12	Date
1													T	T	T	T									1
2																									2
3																									3
4																									4
5																									5
6	T	T		T	T					T	.05	.13	.17	.14	.09	T	T	.01	T						6
7										T	T	T													7
8						T		T	.02	T	.02				T			T	T	T	.08	.40	.40	.31	8
9	.11	T	T	.05	.02	T	.01	T	T	T															9
10																									10
11																									11
12																						T	T	.07	12
13	.05	.03	.04	.02	.09	.00	.11	.01	.02	.05	.15	.11	.07	.08	.13	.14	.10	.02	.04	.01	.01	.01	T		13
14			T	T	T	T															T				14
15																									15
16																									16
17					T				T	T	.03	.01	.01	T	.38	.18	.01	.01	T						17
18																									18
19													T	.05	.23	.31	.15	.06	.07	.09	.07	.06	.06	.08	19
20	.05	.01	.06	.08	.02	.05	.11	.11	T	T	T	T	T												20
21																									21
22												T													22
23																									23
24																								T	24
25	T	.23	.06	.04	.07	.07	.09	.16	.14	.11	T	T		T	T	.01	.01	.02	.02	.11	.01	T	T	.11	25
26	.27	.01	T	T																					26
27																									27
28																									28
29																									29
30																									30
31																									31

OBSERVATIONS AT 3-HOUR INTERVALS

Hour	Sky cover (tenths)	Ceiling (hundreds of ft)	Visibility (whole miles)	Visibility (16ths)	Weather	Temperature Air °F	Wet bulb °F	Dew pt. °F	Rel. hum. %	Wind dir	Wind speed knots
					DAY 01						
01	10	16	6		F	39	39	38	98	04	5
04	10	22	6		F	39	38	37	93	03	3
07	10	21	6		F	38	38	37	96	00	0
10	10	20	6		F	41	39	38	89	09	3
13	10	13	3		QF	41	40	39	93	20	6
16	10	5	3		F	41	41	41	100	22	7
19	10	7	3		F	42	42	42	100	21	7
22	7	15	5		F	42	42	41	96	24	6
					DAY 02						
01	3	UNL	2		F	38	38	38	100	24	7
04	0	UNL	15			36	33	28	73	30	9
07	6	UNL	15			31	29	24	75	31	7
10	3	UNL	15			37	31	21	52	30	11
13	2	UNL	15			41	33	18	40	30	11
16	8	UNL	15			41	33	19	41	29	10
19	5	UNL	15			30	27	20	66	00	0
22	4	UNL	15			28	26	20	72	25	4
					DAY 03						
01	0	UNL	20			24	23	19	81	20	3
04	0	UNL	20			23	22	17	78	23	5
07	0	UNL	15			27	23	12	53	32	8
10	0	UNL	25			34	27	12	40	30	7
13	0	UNL	25			40	30	08	26	31	11
16	0	UNL	25			41	31	10	28	28	9
19	0	UNL	25			29	25	16	58	13	7
22	0	UNL	25			25	23	16	69	00	0
					DAY 04						
01	8	UNL	25			21	20	15	78	35	4
04	7	UNL	25			20	19	15	81	02	4
07	0	UNL	25			21	19	12	68	05	4
10	0	UNL	15			32	28	20	61	06	5
13	5	UNL	20			44	33	14	30	24	7
16	2	UNL	20			41	35	12	24	22	7
19	1	UNL	12			34	28	16	48	13	4
22	4	UNL	15			33	27	16	50	18	4
					DAY 05						
01	2	UNL	20			32	27	16	52	20	4
04	8	UNL	20			30	26	17	58	21	4
07	9	UNL	15			27	24	16	63	00	0
10	2	UNL	12			38	32	21	49	20	3
13	7	250	12			51	40	23	33	25	7
16	10	250	15			55	42	21	28	20	6
19	4	UNL	12			43	38	31	68	17	4
22	8	90	12			47	42	35	63	16	5
					DAY 06						
01	10	50	10		R	48	46	42	77	22	3
04	9	65	10		R	45	45	45	100	24	5
07	8	25	7			43	43	43	100	00	0
10	10	80	6		F	48	47	46	96	08	4
13	10	13	1		RF	48	48	48	100	35	4
16	10	3	1	8	LF	48	48	48	100	12	6
19	10	2	0	6	F	48	48	48	100	11	5
22	10	0	0	2	F	48	48	48	100	21	4
					DAY 07						
01	10	1	0	2	F	46	46	46	100	35	7
04	10	1	0	4	F	42	42	42	100	35	6
07	10	3	1		F	41	41	41	100	02	3
10	10	3	1	8	LF	42	42	42	100	03	5
13	10	5	2	8	F	43	43	43	100	03	5
16	10	5	2	8	F	44	44	44	100	08	5
19	10	1	0	8	F	43	43	43	100	03	3
22	10	1	0	8	F	43	43	43	100	09	5
					DAY 08						
01	10	4	1		F	44	44	44	100	11	8
04	10	5	2		F	45	45	45	100	11	10
07	10	5	2	8	F	45	45	45	100	12	10
10	10	3	1		F	52	52	52	100	18	8
13	10	12	7			62	60	58	90	19	12
16	10	10	10			67	63	61	81	18	14
19	10	27	12		R	65	62	61	87	19	15
22	10	65	4		RW	63	62	62	97	19	16
					DAY 09						
01	10	13	8		RF	62	61	61	97	23	10
04	10	4	2		R	41	41	41	100	31	20
07	10	18	5		S	34	32	29	82	30	12
10	5	UNL	20			27	24	15	61	27	20
13	0	UNL	30			28	23	09	45	28	15
16	0	UNL	30			29	24	09	43	28	20
19	0	UNL	35			26	21	07	44	29	12
22	0	UNL	35			21	16	00	40	30	8
					DAY 10						
01	0	UNL	35			17	13	02	43	28	10
04	0	UNL	35			14	11	00	53	30	8
07	0	UNL	35			12	10	-01	56	29	11
10	0	UNL	30			18	14	00	45	28	13
13	0	UNL	30			25	19	00	33	29	13
16	0	UNL	30			28	21	00	30	28	10
19	0	UNL	40			23	18	01	35	28	11
22	0	UNL	40			19	15	00	41	27	9
					DAY 11						
01	0	UNL	30			15	12	01	54	25	7
04	0	UNL	30			14	11	02	46	32	8
07	0	UNL	30			10	08	00	64	24	5
10	1	UNL	30			19	15	02	47	34	9
13	0	UNL	30			31	23	02	29	31	8
16	3	UNL	30			35	26	03	26	30	5
19	2	UNL	35			30	23	07	38	20	4
22	0	UNL	30			22	19	08	57	21	4
					DAY 12						
01	0	UNL	25			21	19	12	68	00	0
04	0	UNL	25			17	16	11	77	00	0
07	0	UNL	20			14	14	12	92	00	0
10	8	UNL	15			32	26	14	47	00	0
13	6	UNL	15			42	31	08	24	12	4
16	10	100	12			42	31	10	27	14	8
19	10	130	20			37	29	13	37	12	4
22	10	24	12		IP	37	29	14	39	06	5
					DAY 13						
01	10	20	2	8	ZR	33	33	32	96	05	9
04	10	8	4		ZRF	32	32	32	100	02	10
07	10	8	2	8	ZRF	33	33	33	100	01	[illegible]
10	10	8	4		RF	34	34	34	100	02	6
13	10	4	4		RF	34	34	34	100	36	8
16	10	4	2		RF	34	34	34	100	02	9
19	10	4	2		RF	34	34	34	100	34	7
22	10	6	1		RF	34	34	34	100	32	7
					DAY 14						
01	10	10	6		F	35	35	35	100	28	7
04	10	21	2		S	34	34	34	100	29	6
07	10	27	2		F	35	35	35	100	24	6
10	10	27	1		F	37	37	37	100	21	8
13	10	35	7			41	38	35	79	31	8
16	8	28	8			39	36	32	76	31	6
19	10	50	8			37	35	32	82	33	1
22	10	19	8			36	34	32	85	29	7
					DAY 15						
01	10	90	8			33	30	26	75	29	10
04	10	19	10			31	29	25	78	30	13
07	9	40	12			31	28	24	75	28	10
10	2	UNL	12			33	29	23	67	29	10
13	9	31	20			35	29	22	64	31	15
16	2	UNL	20			37	31	20	50	26	15
19	0	UNL	20			32	28	20	61	31	7
22	0	UNL	20			28	26	20	72	26	6
					DAY 16						
01	0	UNL	20			28	24	17	69	20	7
04	0	UNL	15			20	19	16	84	00	0
07	0	UNL	15			18	18	16	92	11	4
10	8	UNL	10			31	26	15	51	02	3
13	10	250	15			38	29	12	34	14	7
16	10	250	20			40	32	17	39	17	5
19	10	100	20			35	30	21	57	05	4
22	10	120	20			35	30	20	54	06	5
					DAY 17						
01	10	20	15			36	30	18	48	12	8
04	10	27	15			36	31	23	55	10	6
07	10	33	12			36	33	27	70	07	5
10	10	10	10			41	38	37	86	07	6
13	10	2	1		F	46	46	46	100	07	10
16	10	4	2		RF	50	50	50	100	00	0
19	10	1	1	8	F	45	45	45	100	28	10
22	10	2	1		F	39	39	39	100	29	8
					DAY 18						
01	10	1	0	12	F	37	37	37	100	25	7
04	10	1	0	12	F	38	38	38	100	26	7
07	10	3	1	8	F	37	37	37	100	27	8
10	0	UNL	10			42	41	38	89	26	8
13	0	UNL	15			48	43	38	61	30	13
16	5	UNL	15			48	43	35	59	31	9
19	3	UNL	20			40	37	33	76	34	7
22	4	UNL	20			31	31	30	96	03	6

NOTES

CEILING
UNL INDICATES UNLIMITED

WEATHER
- + TORNADO
- T THUNDERSTORM
- Q SQUALL
- R RAIN
- RW RAIN SHOWERS
- ZR FREEZING RAIN
- L DRIZZLE
- ZL FREEZING DRIZZLE
- S SNOW
- SP SNOW PELLETS
- IC ICE CRYSTALS
- SW SNOW SHOWERS
- SG SNOW GRAINS
- IP ICE PELLETS
- A HAIL
- F FOG
- IF ICE FOG
- GF GROUND FOG
- BD BLOWING DUST
- BN BLOWING SAND
- BS BLOWING SNOW
- BY BLOWING SPRAY
- K SMOKE
- H HAZE
- D DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH; I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS; MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

OBSERVATIONS AT 3-HOUR INTERVALS

Hour	Sky cover (tenths)	Ceiling (hund. of ft.)	Visibility whole miles	Visibility tenths mile	Weather	Temp. air °F	Temp. wet bulb °F	Temp. dew pt. °F	Rel. hum. %	Wind dir	Wind speed knots
DAY 19											
01	8	250	4			32	31	30	92	33	6
04	10	12	7			33	32	20	85	05	7
07	8	200	10			31	29	24	74	05	8
10	10	30	7			34	31	28	73	05	8
13	10	21	.4		RF	33	32	29	85	03	6
16	10	5	2		ZRF	33	33	33	100	01	4
19	10	7	2		RF	34	34	34	100	01	4
22	10	7	4		RF	34	34	34	100	01	6
DAY 22											
01	10	UNL	15			28	26	21	75	33	5
04	10	UNL	15			27	25	21	78	32	3
07	9	250	10			25	24	21	85	36	4
10	10	100	8			28	26	21	75	36	8
13	10	90	8			32	29	22	67	05	4
16	10	60	8			29	31	24	84	28	5
19	10	75	12			33	30	24	70	33	4
22	7	75	15			31	26	26	82	00	0
DAY 25											
01	10	19	8		R	40	39	38	93	35	6
04	10	9	4		RF	38	38	38	100	04	5
07	10	2	2		RWF	42	42	42	100	06	7
10	10	10	7		R	63	62	61	93	18	17
13	10	11	10			68	64	62	81	20	18
16	10	11	7		R	64	63	62	93	17	11
19	10	9	7		R	62	61	60	93	14	13
22	10	14	7			65	63	62	90	16	25
DAY 28											
01	0	UNL	30			31	26	14	48	30	8
04	0	UNL	40			28	24	13	53	25	7
07	7	UNL	40			28	23	15	63	29	7
10	0	UNL	20			31	27	18	59	26	14
13	0	UNL	20			36	29	13	39	30	12
16	7	65	20			38	29	16	44	29	16
19	0	UNL	20			27	22	06	40	32	16
22	0	UNL	20			24	20	07	48	30	10
DAY 31											
01	0	UNL	20			21	20	19	78	00	0
04	0	UNL	15			16	16	15	96	00	0
07	6	UNL	15			18	18	13	88	00	0
10	10	90	12			27	25	20	75	26	3
13	2	UNL	15			38	30	14	37	28	8
16	3	UNL	20			38	30	14	37	32	14
19	1	UNL	25			30	25	13	49	32	9
22	2	UNL	25			26	22	12	55	31	6

Hour	Sky cover (tenths)	Ceiling (hund. of ft.)	Visibility whole miles	Visibility tenths mile	Weather	Temp. air °F	Temp. wet bulb °F	Temp. dew pt. °F	Rel. hum. %	Wind dir	Wind speed knots
DAY 20											
01	10	8	5		RF	34	34	34	100	02	8
04	10	5	3		RF	34	34	34	100	35	7
07	10	5	5		RF	35	34	34	100	02	7
10	10	4	2		LF	34	34	34	100	32	5
13	10	4	5		F	34	34	34	100	28	8
16	10	4	6		F	37	37	36	96	25	0
19	2	UNL	8			35	35	34	96	23	5
22	7	UNL	2	8	F	34	34	34	100	27	5
DAY 23											
01	0	UNL	12			26	28	24	96	00	0
04	0	UNL	8			22	22	21	96	04	3
07	0	UNL	2	8	F	20	20	20	100	05	3
10	1	UNL	5		F	34	32	29	82	08	3
13	1	UNL	8			42	35	24	49	35	4
16	6	250	10			44	36	23	44	35	4
19	0	UNL	15			35	31	25	67	01	5
22	0	UNL	15			30	29	27	92	00	0
DAY 26											
01	10	8	3		RF	57	56	55	93	25	14
04	10	34	8			50	48	42	[illegible]	21	20
07	6	39	8			43	38	32	65	23	22
10	3	UNL	25			42	35	24	49	23	23
13	3	UNL	25			43	36	25	48	22	26
16	1	UNL	25			38	29	13	39	26	28
19	0	UNL	15			29	23	06	37	25	15
22	0	UNL	15			25	20	07	46	22	18
DAY 29											
01	7	UNL	35			22	19	07	52	29	5
04	0	UNL	30			16	18	09	66	27	7
07	3	UNL	25			16	15	10	77	29	5
10	1	UNL	20			25	22	12	56	34	10
13	0	UNL	25			30	24	08	38	29	14
16	0	UNL	25			34	27	10	36	30	10
19	0	UNL	25			29	24	10	45	32	10
22	0	UNL	25			24	18	-05	27	31	13

Hour	Sky cover (tenths)	Ceiling (hund. of ft.)	Visibility whole miles	Visibility tenths mile	Weather	Temp. air °F	Temp. wet bulb °F	Temp. dew pt. °F	Rel. hum. %	Wind dir	Wind speed knots
DAY 21											
01	10	37	9		F	34	33	31	88	27	8
04	10	38	9		F	33	32	29	89	27	7
07	0	UNL	7			29	28	25	85	28	7
10	0	UNL	10			34	30	24	67	29	10
13	4	UNL	10			37	33	27	67	31	12
16	3	UNL	10			39	34	27	62	27	13
19	2	UNL	12			33	30	26	75	28	7
22	7	UNL	15			30	28	26	85	28	6
DAY 24											
01	0	UNL	15			27	27	26	96	02	3
04	0	UNL	10			25	25	24	96	00	0
07	8	UNL	7			25	26	24	82	11	3
10	10	200	7			34	32	29	78	31	4
13	10	200	10			42	38	28	44	14	7
16	10	200	12			50	41	28	44	13	6
19	10	250	10			42	37	28	60	12	4
22	10	60	10			42	37	30	63	09	4
DAY 27											
01	0	UNL	15			25	22	12	58	22	14
04	0	UNL	15			25	22	14	63	22	15
07	0	UNL	14			25	22	15	68	21	14
10	0	UNL	25			32	27	17	54	24	18
13	0	UNL	25			41	32	14	33	24	13
16	1	UNL	25			43	33	14	31	23	17
19	0	UNL	20			34	27	13	42	20	5
22	0	UNL	15			30	25	15	54	24	7
DAY 30											
01	0	UNL	35			21	18	07	55	31	8
04	0	UNL	35			18	16	04	52	28	8
07	0	UNL	35			18	14	07	67	28	5
10	1	UNL	30			25	21	08	90	33	10
13	0	UNL	25			33	25	10	38	29	8
16	8	250	25			38	26	11	35	28	8
19	1	UNL	25			29	24	12	40	24	5
22	2	UNL	25			25	22	13	60	00	0

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SYNERGY

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SOLAR DOMESTIC HOT WATER HEATING SYSTEMS

The homeowner interested in utilizing solar energy to reduce energy bills and help preserve fossil fuel supplies should consider installing a solar domestic hot water heating system. These systems have several advantages over solar space heating systems, namely:

(1) They have a reasonable first cost - system prices vary between $700 and $2,500 depending on system size and installation costs. A small system installed by a skilled homeowner would be the most inexpensive.

(2) They have a short economic return period - hot water heaters operate year round rather than only during the heating season and can account for as much as 30% of your heating energy bill. Thus the initial investment can be recovered in reduced energy bills in four to ten years, depending on initial cost and type of energy being replaced.

(3) They can be easily retrofitted on existing houses due to the small collector area (less than 100 square feet), small storage tank size (80 - 120 gallons and the capacity to be easily plumbed into the existing conventional hot water heating system.

OPERATING PRINCIPLES OF A SOLAR DOMESTIC HOT WATER HEATING SYSTEM

The main components of a solar domestic hot water heating system are (refer to Figure 1):

(1) Solar Collector Panels - these are flat plate, air or liquid collectors. Air collectors heat the air which is circulated through them. This heated air passes over an air to water heat exchanger (the radiator in your car is an example of an air to water heat exchanger) thus causing potable water circulating through the heat exchanger to be heated. Liquid collectors operate as either closed or open systems. A closed system circulates an anti-freeze solution which picks up heat from the collector and transfers the heat to the potable water through a heat exchanger. An open system circulates potable water through the collector. When an open system is not operating, the water drains down into the storage tank to prevent freezing problems.

(2) Solar Storage Tank - this is basically a conventional hot water tank without the heating unit, and sized to meet the family needs (usually 60 to 120 gallon capacity).

(3) Associated Plumbing Fixtures - pumps, valves and temperature sensors are necessary to activate the system, circulate the fluid, and safeguard against overheating or high pressure.

The solar domestic hot water heating system operates as follows, (assume a closed system):

(1) Cold water flows into the solar storage tank.

(2) When the temperature at the collector sensor is higher than the temperature at the tank sensor, the pump is activated which circulates the anti-freeze solution.

(3) The solution absorbs heat as it passes through the collector.

(4) The solution transfers the heat to the potable water as it passes through the heat exchanger.

(5) The heated water is stored in the solar storage tank.

(6) When hot water is needed in the house (for a shower, etc.), it is drawn from the conventional hot water tank.

(7) The conventional hot water tank is replenished with water from the solar storage tank.

(8) If the solar heated water is not at the required temperature, the conventional tank will switch on and heat the water as needed.

SIZING A SOLAR DOMESTIC HOT WATER HEATING SYSTEM

A solar domestic hot water heating system can be sized to economically provide up to 75% of the hot water needs of a house in North Carolina. Thus a conventional system will be needed as a backup to provide the remaining 25%. Systems which are 100% solar are not economically feasible.

To size a system for your house, assume every household member uses 20 gallons of hot water per day. Thus a family of four would require 80 gallons of hot water per day. A solar system to provide 75% solar heated water requires a collector area equal to 1 square foot of collector for each gallon of hot water needed each day. So the family of four would require a collector area of 80 square feet. The solar storage tank size required is equal to the hot water needs of the family in a day, or 80 gallons for the family of four.

Solar domestic hot water heating systems can be smaller in size and operate more efficiently if conservation measures are also employed. Conservation measures which can reduce energy consumption include:

(1) Reducing hot water temperature to 120° - 130°F, (this is an adequate temperature for all household operations except automatic dishwashing).

(2) Using warm or cold water cycles in clothes washing.

(3) Installing shower head flow restrictors and/or taking more short showers and fewer baths.

(4) Repairing leaks.

(5) Conscientiously turning off water taps.

PURCHASING AND INSTALLING A SOLAR DOMESTIC HOT WATER HEATING SYSTEM

Solar hot water systems can be installed by a homeowner who possesses basic plumbing skills or by knowledgeable plumbing contractors. When buying a system, exercise the same judgement as when making any major purchase. Specifically, use the following criteria:

(1) Is the unit reliable and durable - you are purchasing a system which should last 20 years, examine the materials and construction methods used.

(2) Is the contractor or manufacturer reputable - the solar energy ndustry is very young and there are many unproven businesses flourishing. Examine the company's past record, if possible. Check if warranties are offered. Ask about availability of replacement parts and service.

(3) Check with local plumbing codes before purchasing or installing.

Installation of the system is fairly simple due to its small size. The collectors require an area of less than 100 square feet. They must be oriented within 20° of due south and tilted at an angle of 30° to 50°. The solar storage tank is only slightly larger than a conventional tank and should be installed as close to that tank as possible. The use of a liquid system requires only pipes (as compared to ducts in an air system) for connection between collector and tank making a retrofit installation easier.

Because of the relative low initial cost, relative short economic payback period, and compact size, a solar domestic hot water heating system is a very realistic way for a homeowner to make a committment to solar energy.

NOTE: All piping shown 3/4".

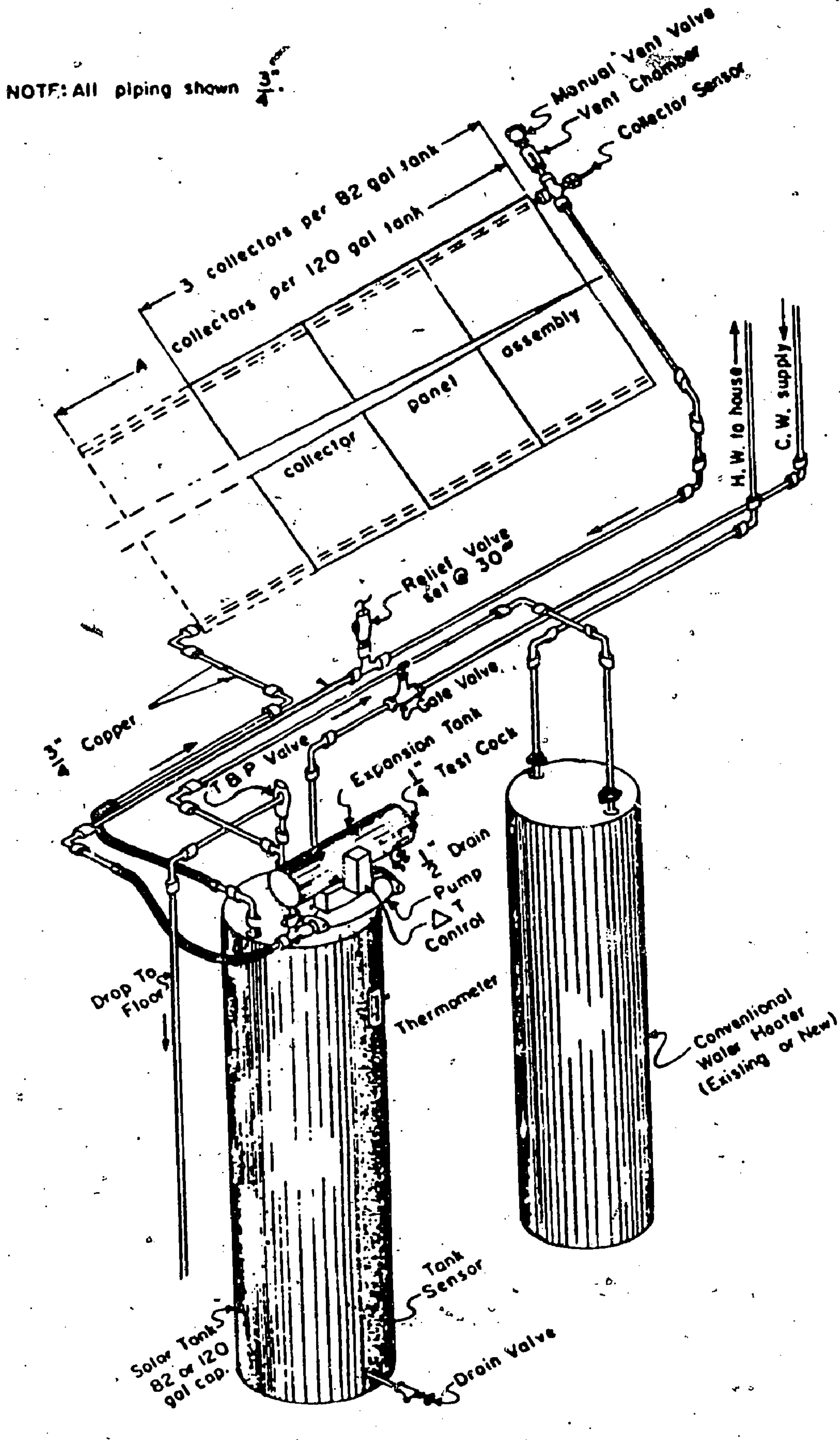

Figure 1

SOLAR HEATED DOMESTIC WATER SYSTEM

north carolina
AGRICULTURAL EXTENSION SERVICE
a&t and n.c. state universities

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Mat Heyman
301/921-3181

78-21

EFFECTIVENESS OF ATTIC AND WHOLE-HOUSE VENTILATION EXAMINED*

In a study cosponsored by the Commerce Department's National Bureau of Standards (NBS) and the U.S. Department of Energy, researchers found that ventilating a residence with a whole-house fan instead of cooling it with an air conditioner can be a very effective way to save energy. At the same time, they report that attic ventilation used in conjunction with air-conditioning may not be as effective in saving on air-conditioning costs as has sometimes been suggested.

These findings are based on experiments involving various types of ventilating equipment installed in three test houses in Houston, Texas. The American Ventilation Association (AVA) provided the houses. Both the AVA and the Home Ventilating Institute cooperated in planning the project and test procedures.

In the NBS tests, a whole-house fan was used instead of an air conditioner whenever the outside temperature dropped below 82 °F (28 °C). Data gathered from the tests suggested that substantial energy savings could be achieved in the southern United States by using this procedure, with exact savings depending on geographic location.

*Reprinted with permission of the National Bureau of Standards.

The data also gave a general indication that "Whole-house ventilation may be used instead of air conditioning to provide indoor comfort during a significant portion of the summer cooling season in the northern half of the United States. Since a whole-house fan consumes considerably less energy than a central air conditioner, the energy savings may be expected to be considerable."

In separate tests on the Houston houses, several different kinds of attic ventilation equipment--both powered and natural--were installed to provide extra ventilation in the attic space. Based on these tests, NBS engineers found that adding attic ventilation "was not an effective energy conservation procedure for those houses which had moderately insulated attics."

The extra ventilation was found to produce less than a three percent reduction in the daily cooling loads for the test houses. Over the course of the day, the energy consumed by power attic fans exceeded the amount of energy they saved by lowering the air-conditioning energy requirements.

NBS researchers noted that their findings were limited to data gathered from the three Houston test residences and that the conclusions cannot yet be applied to all types of houses in all areas of the country. NBS and others are conducting further work on this problem.

The NBS research results were presented during a workshop on whole-house and attic ventilation sponsored by the NBS Center for Building Technology on July 13, 1978. Results from several other ventilation studies undertaken by universities and utilities were also presented at the meeting. Four other papers, including two which summarized other DOE-sponsored research, contained findings on the performance of attic ventilation similar to the NBS conclusion. In contrast, one utility reported substantial air-conditioning savings with increased attic ventilation.

Both attic and whole-house ventilation have been suggested as having the potential for saving on summer air-conditioning costs, but there has been a scarcity of research to document their energy effectiveness. (There is, however, little doubt that adequate attic ventilation is important in order to prevent harmful moisture from condensing in the attic areas during winter months.) The NBS research was designed to answer some of the outstanding questions about ventilation in terms of its energy effectiveness. The workshop provided a forum for technical discussions about the subject.

Engineer Doug Burch, a principal NBS researcher on the project, stressed that "These findings should not be viewed as the last word on the energy effectiveness of ventilation." He noted that there are still many problems in trying to quantify the exact energy impact of ventilation in houses. But according to Burch, "The NBS research and the other studies reported on at the workshop go a long way in helping to answer questions about whether or not whole-house and attic ventilation are effective energy answers."

NOTE TO EDITORS AND CORRESPONDENTS: The complete report on the NBS Houston tests is not yet assembled. A summary of the report and copies of other papers presented at today's workshops are available by writing or calling Mat Heyman in the NBS Media-Liaison Office, National Bureau of Standards, Washington, D.C. 20234, 301/921-3181.

FACT SHEET

NBS/DOE TESTS ON ATTIC AND WHOLE-HOUSE VENTILATION

From July through October, 1977, the Commerce Department's National Bureau of Standards (NBS) conducted a series of tests for the U.S. Department of Energy (DOE) that focused on the energy effectiveness of attic and whole-house ventilation. Both types of ventilation have been suggested as having the potential for reducing summer air-conditioning costs.

In the past, the whole-house fan was often referred to as an attic fan. Actually, attic fans are power devices used to ventilate attic spaces, while a whole-house fan is mounted in the ceiling of the living area or in the outside wall of the attic and primarily ventilates the living area of the house. The whole-house fan provides a cooling effect in the living space by drawing a breeze through open windows and exhausting the air through openings in the attic, thereby, also ventilating the attic area.

The research, cosponsored by NBS and DOE, is part of a larger, ongoing DOE program of research into ventilation and energy conservation. The American Ventilation Association (AVA) provided three test houses in Houston, Texas, which were used for the research project. Both the AVA and the Home Ventilating Institute cooperated with NBS in drawing up the research plan, test procedures, and installations before and during the tests.

The test houses used in the NBS study were new, wood-frame ramblers with brick veneer outer covering. They were constructed over a slab-on-grade and had gable roofs with light brown shingles. The floor plan, orientation, and construction details for the houses were identical. One house had 16.5 cm (6.5 in.) of rock wool ceiling insulation; the others had 10 cm (4 in.) Indoor air temperatures were set at the same levels. Although they were unoccupied during testing, the heat given off by lighting, equipment, and occupants was simulated. Each house was extensively instrumented.

The houses were equipped with several different kinds of ventilation systems. In the attic, in addition to the soffit (eave) vents which met requirements of the Department of Housing and Urban Development/Federal Housing Administration Minimum Property Standard, the houses had two wind-driven turbines, one roof-mounted attic ventilator, and one continuous ridge vent. Each house also had a whole-house fan installed that was not used when just the attic ventilation systems were being tested.

During the whole-house ventilation tests, the whole-house fan was turned on and the windows were opened in one residence whenever the temperature outside dropped below 82 °F (28 °C). The air conditioner was used only when the temperature rose above 82 °F (28 °C). The energy used

in this situation was compared against the energy it consumed when just the air conditioner was used. The test showed that the cooling energy requirement was substantially reduced when whole-house ventilation was utilized. For instance, when the daily-average outdoor temperature was 76 °F (24 °C), the whole-house fan reduced the cooling energy requirement by nearly two-thirds.

NBS investigators also performed an analysis of the indoor comfort conditions as part of the whole-house fan tests. The analysis suggested that sedentary occupants would experience comfortable conditions when the outdoor temperature was 82 °F (28 °C)) and the outdoor humidity was as high as 75 percent. However, it was determined that occupants performing moderate work under those circumstances would experience comfort levels in the warm to slightly warm range. This led researchers to suggest that it may be desirable to limit use of the whole-house fan in air-conditioned residences when moderate work is planned during particularly hot, humid hours.

During the attic ventilation testing, researchers sealed off ventilation openings which were not a part of the particular equipment testing sequence. In most instances, test periods lasted one week. While the tests showed that a variety of attic ventilation devices lowered the temperatures of the attic space and consequently cut down on the heat gain through the ceiling and into air-conditioning ducts located in the attic space, those heat gains represent only small fractions of the daily cooling load of the air conditioner. At maximum load condition, the increased ventilation produced a 25 percent and 16 percent reduction in the ceiling and duct heat gain rates, respectively. However, these reductions only lowered the cooling load by six percent.

The researchers found that "when the effect of reducing ceiling and duct heat gains were considered over a period of a day, attic ventilation was found to produce less than a three percent reduction on the daily cooling loads for the test houses." Power fans used more energy than they saved in the NBS test houses over a full day.

Under the test conditions, attic ventilation was shown to have an insignificant effect on the indoor comfort condition. The reductions in ceiling temperatures which resulted from use of various attic ventilation systems as compared to just soffit venting were shown to be less than 1 °F (0.6 °C), an amount that would not significantly impact the indoor comfort conditions.

SLIDE DESCRIPTIONS*

4 1. A heat pump is a good energy choice. Look for a unit with a high EER, e.g., 10.

4 2. Where possible, place the outdoor unit in a shady spot or the north side of the home.

4 3. Nice placement of return registers in staircase.

4 4. Solar water heating is now cost effective when compared to electric water heating and considering the state tax credit.

4 5. Two solar water heater panels by Revere, installed on a relatively flat roof by Sunspot Solar Products, Inc.

4 6. Active solar heating system using site-built air panels by Fitch Creations.

4 7. Active solar heating system using liquid collectors on custom house by Solomon & Reuben. This house won the region design award from NCHBA.

4 8. Wood stoves are another heating alternative. Jotul wood stoves are popular, well built, Norwegian stoves. This unit is in a Solomon & Reuben spec house. Jotul #1 combi, $540.

4 9. Jotul #6 fireplace/wood stove. $900.

4 10. Lange wood stoves come in nice enamel colors. This one costs about $600, without enamel, $470.

4 11. Morso 2BO wood stove with heat chamber. $520.

4 12. Petit Godin wood and coal stoves, $325-450.

4 13. Glass fireplace doors are best used at night before bed when fire is still going. They should be left open during normal use.

4 14. Outside combustion air intake can be nearly invisible and costs very little to install. Greatly reduced infiltration to house.

4 15. Exterior fireplaces lose heat when there is not a fire and waste a great deal of usable heat when fire is going. Install on interior wall.

4 16. Clock thermostats generally show a payback time of less than 2 years.

4 17. 24-hour timer saves energy on many appliances including electric water heater.

*See page 3 for information on obtaining slides.

4 18. Install water flow restrictors, low flush toilets, aerators, etc.

4 19. IR lamps in bath can save energy by allowing higher spot temperature.

4 20. Electric demand-type water heater has no storage so saves about 40%, or $40-60/yr; costs about $150.

4 21. Gas demand-type water heater.

4 22. This range hood filters then recycles hot air, which is good in winter, bad in summer.

4 23. Insulate hot water pipes.

4 24. Instead of using plywood on the corners, use steel straps, then continue insulating sheathing around corner.

111

OTHER REFERENCES AND RESOURCES

1. Eccli, E., ed., Low Cost Energy Efficient Shelter. Emmaus, PA: Rodale Press, Inc., 1976.

   Contains many simple, yet effective ideas aimed primarily at owner-builder, but useful to contractors.

2. Clegg, P. New Low-Cost Sources of Energy for the Home. Charlotte, VT: Garden Way Publishing, 1975.

   Catalog of products and ideas to save energy.

3. SUN Catalog.

   All kinds of energy saving items including wood grates, solar collectors, heat recovery devices, timers, switches, instruments, etc.
   Available for $2.00 from SUN Catalog, Box 306, Bascom, Oregon 44809.

4. Solar Components Catalog.

   Lists many active and passive products such as water columns, collectors, glazing, pumps, valves, beadwall, etc.
   Available free from Kalwall Corp., P.O. Box 237, Manchester, NH 03105.

5. Use and Care of the Electric Heat Pump. Raleigh, NC: Carolina Power and Light Co., 1977.

   Available free from CP&L Customer Service, P.O. Box 1551, Raleigh, NC 27602.

6. 44 ways to Build Energy Conservation into Your Homes, No. 5-BL-7055-A. Toledo, Ohio: Owens-Corning Fiberglas.

   A very good, easy to read pamphlet.
   Available from Owens-Corning Fiberglas, Fiberglas Tower, Toledo, OH 43659.

7. Energy Saving Homes: The Arkansas Story, No. 4-BL-6958-C. Toledo, Ohio: Owens-Corning Fiberglas.

   Available from Owens-Corning Fiberglas (address above).

8. Sh on, Jay and Andrew B. Shapiro. The Woodburner's Encyclopedia. itsfield, VT: Vermont Crossroads Press, 1976.

SECTION 5

Calculating The Cost Of Energy Conservation

SECTION 5. CALCULATING THE COST OF ENERGY CONSERVATION

OBJECTIVE

The builder needs to understand how to put together a package of energy conservation improvements to be used in changing standard house plans. After study of this section the builder will be able to

1. identify feasible elements of an energy conservation package and their approximate cost in relation to overall construction costs;
2. understand importance of proper sizing of heating and cooling equipment in an energy conserving house;
3. calculate the difference in cost of an energy conserving house and a standard house in terms of cost to builder, home buyer, and payback period;
4. explain the energy saving plans and materials that he/she uses to appraisers, lenders, real estate agents, building inspectors and home buyers;
5. calculate heat loss in a house in order to determine necessary heat load; and
6. predict annual energy consumption.

BACKGROUND

Energy Conservation Packages

Perhaps the best way to approach energy conservation from the viewpoint of a home builder is to examine some typical standard house plans and a package of energy conservation features that can be applied to each. This approach will enable a builder to take almost any standard house plan and, using the energy conservation package, alter the plan in an efficient, understandable manner.

The information on the three house plans and the energy conservation package that will be given came from a study done by the Georgia Institute of Technology and is reprinted with their permission (Reference #4). All economic analysis, material cost, utility cost and design elements are particular to the Atlanta area, but the facts are still useful for our purposes since we are comparing the standard house construction to energy conserving house construction within a single location.

Standard House Plans

1. 1200 Plan

1200 sq. ft.	electrical furnace
one story	mechanical air conditioning
slab-on-grade	standard insulation and equipment

2. 1600 Plan

1600 sq. ft.	gas furnace
one story	mechanical air conditioning
crawl space	standard insulation and equipment

3. 2200 Plan

2200 sq. ft.
two stories
full basement

heat pump, two systems (zoned)
standard insulation and equipment

Examine the house plans and construction information for sample standard and energy conserving house plans. (Handouts 20 and 21).

Note that the features included in the sample energy conserving construction are readily available components.

An examination of the features of the energy conservation package and an item breakdown shows the extra cost of materials and the cost per square foot to the builder. (Handout #22).

Now examine the design heating and cooling loads and installed equipment sizes. (Handout #23). The heating and cooling load is greatly reduced in the energy conserving house plans. Remember that oversizing heating and cooling equipment is to be avoided. If possible, the furnace should not be rated much more than 10-20% over the design heat load. An oversized furnace or heat pump cycles excessively. This causes large temperature fluctuations, stratification, and wastes energy by stopping and starting the machine. Like an automobile, the furnace or heat pump runs much more efficiently during steady operation. (References #1 and 2 for principles of calculating heating and cooling loads).

The smaller heating and cooling equipment required because of the energy conservation package results in a savings in equipment cost. (Handout #24).

The savings on installed equipment cost for the 1200, 1600 and 2200 plans are 12%, 22%, and 15%, respectively. These reductions are primarily from reduced tonnage on the air conditioner and heat pump. Smaller savings are from reduced duct and flue size and associated insulation cost. It is obvious that cutting a load in half cannot cut the installed cost in half. The extra cost of a more energy efficient air conditioner (EER 9.0 rather than EER 7.0) is included in "Extra Cost of Materials for Sample Energy Conserving House Plans." (Handout #22).

Annual savings in heating and cooling costs and consumption for the sample standard and energy conserving plans can be estimated based on heat load calculations for the house area and the present cost of energy. (Handout #24). A significant savings is illustrated.

Examine the overall cost difference of the sample standard and energy conserving house plans. (Handout #25). This table summarizes cost data from previous tables. By deducting the HVAC equipment savings from the extra cost of materials for the energy conserving package, the net extra cost to the builder is revealed. The net extra cost to the home buyer is calculated by adding the overhead and profit (30% for purposes of example) to the net extra cost to the builder. The cost per square foot to builder or home buyer is calculated by dividing the net extra cost by the square footage of the house plan used. The annual savings in heating/cooling costs to the home buyer are used to calculate the payback period on the energy conserving package. Methods for calculating the payback period are explained in Handout #26. The first method explained was used here. Inflating energy costs can shorten the payback period. In addition, the energy conservation package will increase the resale value of the house.

Advertising/Explaining Energy Conservation Packages

It is important that home builders know how to explain the energy conservation features of their houses to lenders, appraisers, home buyers, real estate agents and building inspectors. If appraisers do not understand the energy conservation features and what they add to the building cost and value of the house, they will not be able to accurately appraise the house. As a result of an appraisal that does not reflect the true cost and value of the house, lenders may not offer to lend enough money to cover the extra cost of the energy conservation features. Home buyers will want to know why they are asked to pay more for an energy conserving house, and home builders should be able to point out the specific energy conservation features and the estimated savings. Real estate agents also need to be able to make these explanations to home buyers.

An example of a portion of a "FHA Description of Materials Form" is enclosed, (Handout #27) illustrating the type of information that should be given on the energy conservation features of a house. The home builder must be prepared to assist appraisers in understanding the energy conservation features of a house so that this form will accurately reflect the true cost and value of the house.

There are several ways to inform home buyers of the energy conservation features of a house: advertising through media, brochures, certification by local public utility that the house meets their energy efficiency standard, special signs attached to features in house, and use of "Home Energy Profile" cards placed on construction site. (Handout #28).

Calculating Heat Loss

It is occasionally necessary to know how to calculate heat loss in order to compare standard construction with energy conserving construction as a method of providing estimates of energy use and savings. Heat loss calculations can also yield useful information about furnace sizing and whether energy conserving features added to a house are cost effective.

Heat loss can be calculated by several methods. One method is outlined below. Other methods are described in the reference books listed. The method outlined has been done for one of the sample standard house plans and for the same house using the energy conserving package. Blank forms are provided for your calculations. (Handouts #29, 32).

"Residential Energy Conservation Worksheet" (Handout #29). "Heat Loss in a Sample Standard and Energy Conserving House at Winter Design Temperature" (Handout #32).

1. Complete Section I and II of the "Worksheet." The chart on estimated annual energy costs and consumption (Handout #24) was used for the sample calculations given on the completed "Worksheet."
2. Determine area of each different type of exterior surface and enter under Size, Section III of "Worksheet."
3. Itemize materials to be used for floor, wall, ceiling, windows and doors and the R-value of each item and enter under Construction Materials, Section IV of "Worksheet." Refer to "Resistance Values of Structural and Finish Materials, Insulation, Air Spaces, and Surface Films (Handout #30) and to "Typical Insulation Installations" (Handout #11) for a listing of R-values of individual materials. Sum the R-values of the components of each part of house.

4. Estimate the temperature difference between the heated inside area and unheated inside and outside area and enter on Section V of "Worksheet."

$$\text{TD (or } \Delta T^{o}) = \begin{matrix}\text{Temperature}\\ \text{indoors}\end{matrix} - \begin{matrix}\text{Temperature}\\ \text{outdoors}\end{matrix}$$

5. Estimate air leakage (infiltration) using enclosed table, "Infiltration Factors," (Handout #31) and note on Section VI of "Worksheet."

Using the information on the completed "Residential Energy Conservation Worksheet," fill out the form entitled "Heat Loss in a Sample Standard and Energy Conserving House at Winter Design Temperature" (Handout #32) to complete the calculations for heat loss and gain.

6. Determine conduction heat loss through each particular portion of house, e.g., floors, etc. by completing 1-5 of Handout #32 using the following formula:

$$\text{Area} \times \frac{1}{\text{R-Value}} \times \begin{matrix}\text{Temperature}\\ \text{Difference}\end{matrix} (\Delta T^{o}) = \begin{matrix}\text{Heat Loss}\\ \text{in BTU/HR}\end{matrix}$$

7. Calculate infiltration heat loss by completing 6 of Handout #32 using the following formula:

$$.018 \times \text{Volume} \times \#\text{ air changes} \times \Delta T^{o} =$$

8. Sum the heat loss for each particular portion of the house and the infiltration heat loss to get total design heat loss.

Calculating Heat Gain

Calculating cooling loads requires the determining of solar heat gain through unshaded portions of windows. This gain can be significant. Other factors to be considered in cooling calculations are heat gain from people and appliances and latent heat gain. All of these factors must be considered in addition to heat gain for the structure which is calculated as heat loss

is calculated. For complete information on calculating heat gain, see the instructions in Load Calculations for Residential Winter and Summer Air Conditioning: Manual J (Reference #1).

Predicting Annual Energy Consumption

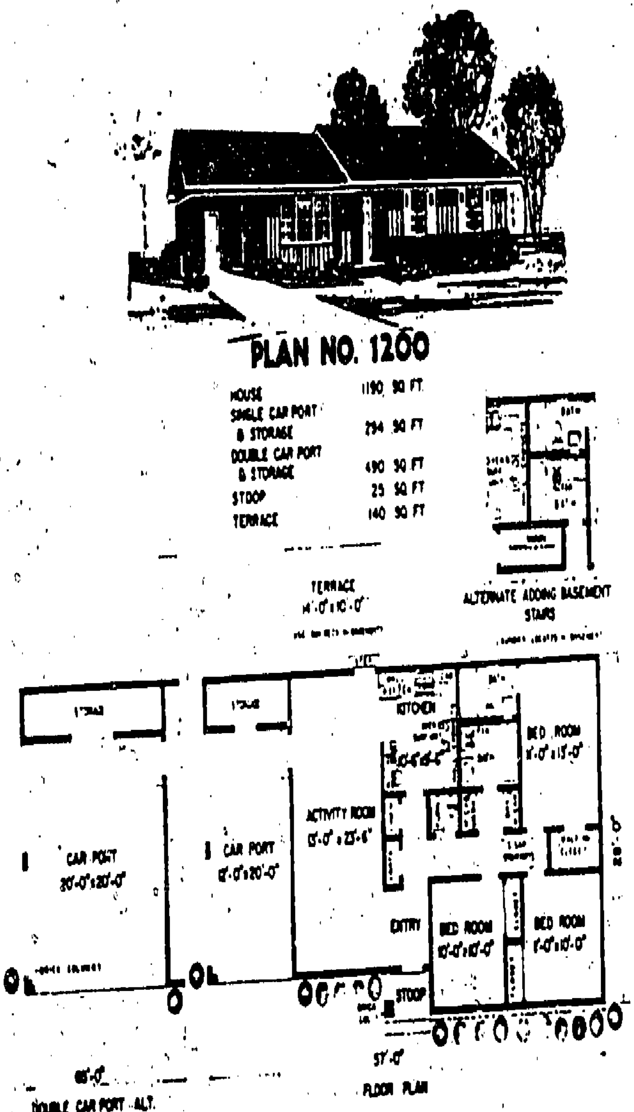
Using the total design heat loss under winter design conditions, the furnace can be sized. Also, knowing the design load, you can predict the annual energy consumption by the method shown on "Estimating Annual Heating Energy Consumption." (Handout #33). Degree day (DD) statistics are available from weather stations (see Local Climatological Data in Section 4), in references listed and on Handout #33.

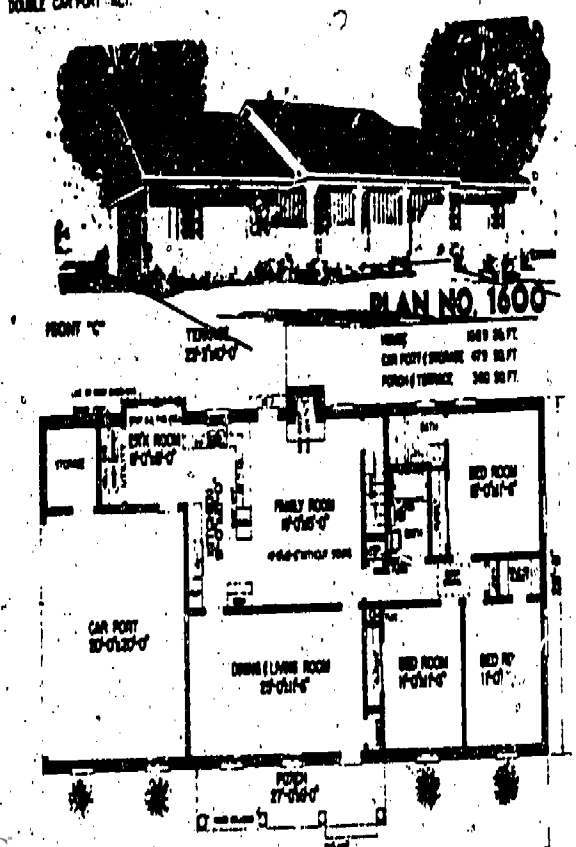
This same type of calculation can be done to determine cooling energy consumption.

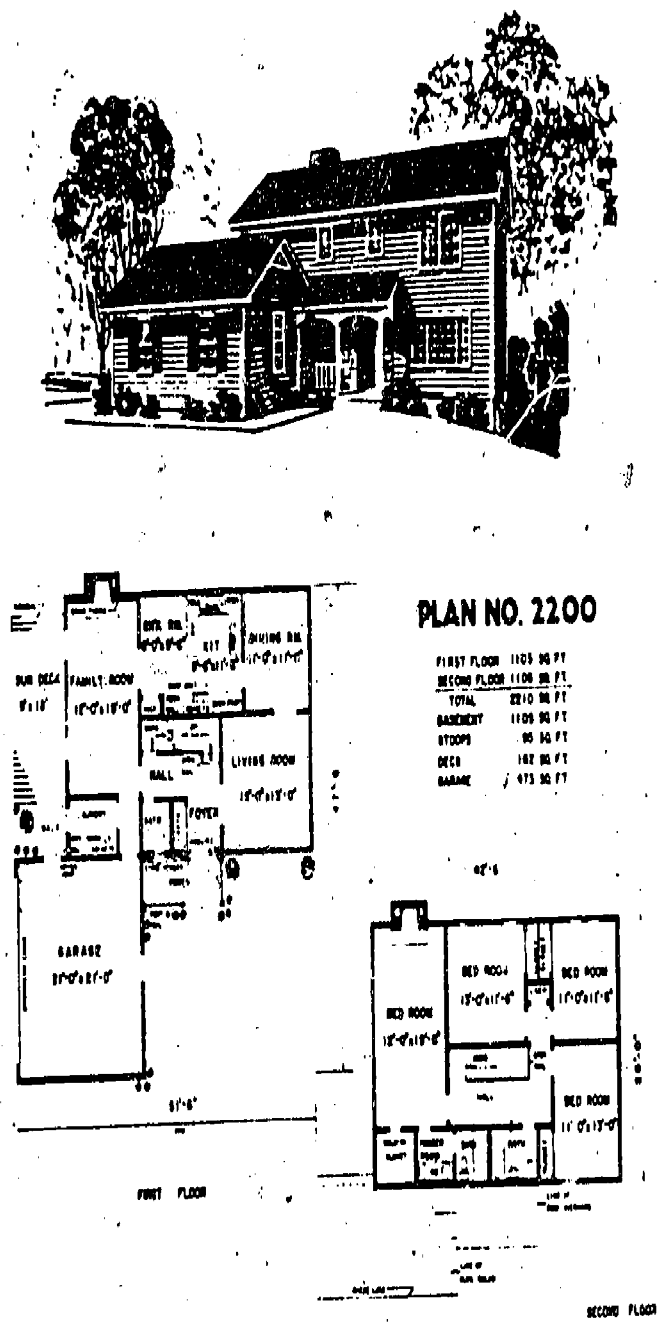
ACTIVITIES

1. Calculate present energy use in a standard house (yours or one you built) using the "Residential Energy Conservation Worksheet" to calculate heat load and "Estimating Annual Heating Energy Consumption."
2. Change construction of house to make it energy conserving by adding insulation, etc. and recalculate.
3. Compare cost of improvement to savings.
4. Fill out "Home Energy Profile" card for a house you are constructing or plan to construct.
5. Design an energy conservation package of features to be used to change a standard house plan that you are currently using.
6. Review "Energy Efficient Residence: EER Research and Demonstration Program," Handout #34. Compare the energy conserving construction details and equipment used in the EER to a similar typical house built locally.

HOUSE PLANS USED IN ENERGY AND ECONOMIC COMPARISON







HANDOUT #20

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CONSTRUCTION INFORMATION FOR SAMPLE STANDARD AND ENERGY CONSERVING HOUSE PLANS

	Standard	Energy Conserving
Ceiling	R-19	R-26 (blown fiberglass)
Walls	R-11	R-13 (batts) + R-4 (Rigid 3/4" Foam)
Floors (1200)	None	1" Rigid Foam
Floors (1600, 2200)	None	R-11
Windows	Single Pane	W/Storm Windows
Doors	Weatherstripped	Insulated Doors
Ducts	2" Duct Insulation	2" Duct Insulation
A/C (1200, 1600)	EER 7.0*	EER 9.0*
Heat Pump (2200)	Two Systems	Two Systems
Other Features:		
	Standard Thermostat	Set Back Thermostat
	Dark Roof	Light-colored Roof
	Roof Louvers	Ridge and Soffit Vents
		Sill Sealer
		Extra Caulking (Wet Foam)
		Tight Construction

*EER - Energy Efficiency Ratio. The higher the EER number, the less electricity the unit will use to cool the same amount of air.

EXTRA COST OF MATERIALS FOR SAMPLE ENERGY CONSERVING HOUSE PLANS

Item	Extra Cost over Standard Construction		
	1200 Plan	1600 Plan	2200 Plan
Storm Windows	$ 200	$ 240	$ 420
Floor Insulation	44	195	139
Attic Insulation	72	97	68
Wall Sheathing-Foam	109	120	200
Wall Insulation-Fiberglass	20	22	36
Insulated Doors-Reg.	105	70	70
Insulated Doors-French	—	75	75
Ridge and Soffit Vents	89	112	61
Sill Sealer	10	12	10
Caulking Pipe holes, Wireholes and Soleplate	120	160	220
Set Back Thermostat	85	85	—
EER 9.0 A/C	150	200	—
TOTAL EXTRA COST TO THE HOME BUILDER	$1,004	$1,388	$1,299
COST PER SQUARE FOOT	$ .84	$ .87	$ .59

DESIGN HEATING AND COOLING LOAD

SAMPLE STANDARD AND ENERGY CONSERVING HOUSE PLANS

HOUSE PLAN	BTUH, Design Load*			
	HEATING		COOLING	
	STD.	EN. CONS.	STD.	EN. CONS.
1200	32,200	15,900	11,200	7,600
1600	48,400	21,300	18,300	10,400
2200	42,400	23,600	21,100	14,600
Average Percent Reduction:	50.3%		35.4%	

*Design load does not include duct loss, latent heat load and equipment efficiency.

INSTALLED EQUIPMENT SIZE

SAMPLE STANDARD AND ENERGY CONSERVING HOUSE PLANS

HOUSE PLAN	HEATING		COOLING	
	STD.	EN. CONS.	STD.	EN. CONS.
1200	16KW	11KW	1-1/2 Ton	1 Ton
1600	80M BTUH	40M BTUH	3 Ton	1-1/2 Ton
2200	3-1/2 Ton	2-1/2 Ton	3-1/2 Ton	2-1/2 Ton

HVAC EQUIPMENT SAVINGS

SAMPLE STANDARD AND ENERGY CONSERVING HOUSE PLANS

House Plan	Standard	En. Cons. Plan	Savings Over Standard Construction
1200	$1,650	$1,450	$200
1600	$2,200	$1,720	$480
2200	$3,960	$3,360	$600

ESTIMATED ANNUAL SAVINGS IN HEATING AND COOLING COSTS AND CONSUMPTION

SAMPLE STANDARD AND ENERGY CONSERVING HOUSE PLANS*

HOUSE PLAN	HEATING		COOLING		ANNUAL SAVINGS
	STD.	EN. CONS.	STD.	EN. CONS.	
1200	$420 12,000 Kwh	$130 3,710 Kwh	$145 3,080 Kwh	$ 70 1,440 Kwh	$365
1600	$260 1,000 Therms	$ 90 340 Therms	$290 6,160 Kwh	$110 2,330 Kwh	$350
2200	$250 7,110 Kwh	$125 3,570 Kwh	$300 6,380 Kwh	$205 4,330 Kwh	$220

*Refer to Georgia study (Reference #4) for more information on how these calculations were performed.

SUMMARY TABLE, COST DIFFERENCE OF SAMPLE STANDARD AND ENERGY CONSERVING HOUSE PLANS

HOUSE PLAN	EXTRA COST OF MATERIAL		HVAC EQUIPMENT SAVINGS		NET EXTRA COST TO BUILDER	NET EXTRA COST TO HOME BUYER	COST TO BUILDER $ PER SQ. FOOT	COST TO HOME BUYER $ PER SQ. FOOT*	ANNUAL SAVINGS IN HEATING/COOLING COST	PAYBACK PERIOD - YEARS
1200	$1004	-	$200	=	$804	$1045	$.67	$.88	$365	3
1600	$1388	-	$480	=	$908	$1180	$.57	$.74	$350	3
2200	$1299	-	$600	=	$699	$920	$.32	$.42	$220	4

*Cost to home buyer per square foot is based on net extra cost of materials to builder per square foot plus the overhead and profit which are calculated at 30% for the purposes of example.

PAYBACK PERIOD

The payback period can be calculated in several ways, two of which are listed below.

1. $$\frac{\text{Total Extra Installed Cost of Energy Conserving Feature}}{\text{First Year Savings in Heating/Cooling Costs}} = \text{Payback Period in years}$$

   - This is a simple, rough estimate that will aid in judging the relative merits of energy conserving features. It does not take into account escalating energy costs, inflation or tax deductible interest rates, all of which can shorten the payback period.

2. If the energy conserving item saves as much per month as it costs in extra mortgage payment per month, it has a payback period of 9.7 years and there is no increased cash flow.

   This method of estimating the payback period does not take into account that the extra mortgage cost increases equity in house, the energy conserving item increases value of house and the mortgage payment is fixed and the interest is tax deductible while energy costs are escalating and are not tax deductible.

If you cannot estimate annual savings for a particular energy conserving item, the manufacturer's literature or the retailer may be able to provide this information.

Note the estimated payback periods for the Energy Conserving House Plans (Handout #25). The extra cost to the home buyer has been divided by the annual savings.

A comparison of standard and energy conserving insulation and building systems on the following page shows estimated payback periods. These figures are from the Georgia study (Reference #4).

A list of other energy conserving equipment with the extra installed cost and estimated payback period from the same study is also given on pages 3 and 4 of this handout.

Refer to Section 1 for an explanation of cash flow and life cycle cost analysis for energy conserving features.

COMPARISON OF INSULATION AND BUILDING SYSTEMS

	PAYBACK PERIOD IN YEARS		
Item	Gas & A/C	All Electric	Heat Pump
Ceilings			
R-30/R-11 Batt*	7	3	6
R-26/R-19 Blown	7	4	6
Cathedral Ceiling			
R-13 + 1" Foam, vented/ R-19, Full Thickness, unvented	45	45	45
R-19, 2 x 8, vented/ R-19, 2 x 6, unvented	16	16	16
Walls			
R-13 + 3/4" Foam/R-11	4	2	3
R-13/R-11	2	1	2
Floors			
Over basement R-11/R-0	6	3	4
Over crawl space R-11/R-0	2	1	2
Windows			
Storm/No Storm	12	5	9
Doors			
Insulated/Wood	2	1	2

*The energy conserving option is listed with the item it is compared to following it. R-30 is energy conserving option/R-11 is standard construction.

ENERGY CONSERVING EQUIPMENT

Item	Extra Installed Cost	Payback Period, Years
Water Saving Shower Head	$ 10	1
Water Saving Aerators	$ 3	1
Low Flush Toilet	None	Save $15/year
Pilotless Ignition on Range	$ 75	11
Water Pipe Insulation, First Foot of Hot & Cold Water Pipe	$ 10	6
Set Back Type Thermostat	$ 85	3
Timer for Electric Water Heater	$ 40	2/3
Humidifier	$100	See Note
Power Roof Vent	$ 75	See Note
Ridge and Soffit Vents	$ 90	10
Heat Reclaimer for Air Conditioner	$550	See Note
Fluorescent Light	$ 15	2

Notes on Energy Conserving Equipment:

Water Saving Shower Head: Cuts flow rate to 3 gpm; 50% reduction in water needs for showering.

Water Saving Aerators: Cuts water flow on sinks to 2 gpm.

Low Flush Toilet: Cuts water use per flush from 5 to 7 gallons to 3 to 3-1/2 gallons. Cuts water bill by 15%.

Pilotless Ignition on Range: Reduction in a gas bill, $7/month. This item is usually available only on top-of-the-line models.

Water Pipe Insulation: Insulating the first 1 and 2 feet of the hot and cold water lines and vent line from the hot water heater can cut these standby losses by 50%.

Set Back Type Thermostat: Reduction in heating bills with 5° night set-back, 11%. Not advisable for heat pump operation.

Timer for Electric Water Heater: Set to heat water 2 hours each morning and evening will save a minimum of $5 per month for a family of four.

Humidifiers: Humidifiers can raise comfort levels in a house. However, they do little to save energy, and may even cause higher heating bills. While a 1° to 2° decreased thermostat setting is possible because of higher humidity, yielding fuel savings, 1,000 btu's are needed to evaporate each pound of water added to the house. It costs 20¢ to 80¢ per day to supply this needed heat if a 13 gpd humidifier is running at full capacity.

In a tightly constructed house with low infiltration rates, the water vapor supplied by cooking, washing, and breathing should be enough to keep humidity at a comfortable level without a humidifier.

Attic Power Roof Vent: Extra cost over roof louvers, $75. With R-19 or better insulation, the fan power consumption may meet or exceed air conditioning savings and, therefore, the fan may never pay for itself. Reduction in ceiling A/C load, 25%. Seasonal power consumption, $12.

Attic Ventilation Note: While attic ventilation in excess of minimum property standards will cut the air conditioning load, the effect is small with large amounts of attic insulation. The continuous ridge and soffit vent is preferred to the power roof vent because of no maintenance, noise, or power consumption.

Ridge and Soffit Vents: Reduction in ceiling air conditioning load, 25%.

Heat Reclaimer for Air Conditioner: These units are composed of a heat exchanger and water pump. They extract heat from the air conditioner and reject it to a pre-heating storage tank for domestic hot water use. They provide hot water and offer a 5 to 10% reduced cost for air conditioning. Problems have been experienced with heat exchanger fouling where drinking water has a high mineral content. Best used where more than 6 months of air conditioning is needed or on all electric houses. Approximate pay-back: 5 years all electric, 14 years with gas/electric.

Fluorescent lights: These produce about 4 times the light per watt of an incandescent bulb. Lower air conditioning costs, and less frequent and therefore lower replacement costs. Best used in bath and kitchen.

TYPICAL ENTRIES FOR FHA 2005
DESCRIPTION OF MATERIALS FORM*

5. EXTERIOR WALLS:
Additional information: Sole plate - latex caulking to flooring

6. FLOOR FRAMING:
Joists: wood, grade, and species ______; other ______; bridging ______; anchors ______
Concrete slab: ☐ basement floor, ☐ first floor, ☐ ground supported, ☐ self-supporting; mix ______; thickness ______";
reinforcing ______; insulation ______; membrane ______
Fill under slab; material ______, thickness ______". Additional information: ______

12. ROOFING:
Additional information: light in color

15. DECORATING: *(Paint, wallpaper, etc.)*
Additional information: Wire and pipe holes latex caulked.

17. WINDOWS:
Weatherstripping: type ______; material ______ Storm sash, number X

18. ENTRANCES AND EXTERIOR DETAIL:
Main entrance door: material See Below; width ______; thickness ______" Frame material ______, thickness ______"
Head flashing ______ Weatherstripping: type Mag. and compression saddles ______
Additional information: Steel faced foam core insulated doors

22. PLUMBING:

Fixture	Number	Location	Make	Mfr's Fixture Identification No.	Size	Color
Water closet	X	X	X	X 3 1/2	Gal. Water Saving	
Bathtub						
Shower over tub△	X	X	X	X 3 GPM	Water Saving	
Stall shower△						
Laundry trays						
Aerators	X	X	X	X 2 GPM	Water Saving	
Water pipes				Pipe Insulation at Hot	Water Heater	

23. HEATING:
Warm air: ☐ Gravity. ☒ Forced. Type of system Gas Furnace
Duct material: supply ______; return ______ Insulation Fiberglass, thickness 2" ☐ Outside air intake.
Furnace: make and model ______ Input ______ Btuh.; output ______ Btuh.
Additional information: Duct joints taped, pilotless ignition on furnace.
Other heating, ventilating, or cooling equipment continuous ridge and soffit vent, EER 9.0 air conditioner, air conditioner heat reclaimer, solar etc.

25. LIGHTING FIXTURES:
Nontypical installation Number and location of Fluorescent light fixture.

26. INSULATION:

Location	Thickness	Material, Type, and Method of Installation	Vapor Barrier
Roof			
Ceiling	R-26	Fiberglass, 8 1/4"	Kraft Face
Wall	R-17	R-13 Fiberglass batt + R-4 rigid foam wall sheathing	Kraft Face
Floor	R-11	Fiberglass batt	Kraft Face
or	R-4	One inch - Beadboard perimeter insulation, 24"	

SPECIAL EQUIPMENT:
Pilotless ignition on range (make and model #)

Also prepare a separate sheet entitled "Addendum to 2005", note section numbers which contain energy conserving items, explain their function if necessary. Make a note on page one of 2005; "To the attention of the appraiser, see Addendum to 2005 on energy conserving items".

*From Building and Marketing the Energy Conserving Home in Georgia 1978-79.

HOME ENERGY PROFILE

THIS HOME CONTAINS THE FOLLOWING ENERGY CONSERVATION FEATURES:

BATT OR BLOWN INSULATION

_______ INCHES — CEILING
_______ INCHES — WALLS
_______ INCHES — FLOORS

FOAM INSULATION

_______ INCHES LOC. AND TYPE _______
_______ INCHES LOC. AND TYPE _______

TOTAL INSUL. 'R' FACTORS

CEILING _______
WALLS _______
FLOORS _______

AIR INFILTRATION BARRIER

- ☐ SILL SEALER
- ☐ WIRING HOLES CAULKED
- ☐ PIPE HOLES CAULKED
- ☐ POLY VAPOR BARRIER
- ☐ ATTIC STAIR SEALED & INSULATED
- ☐ ATTIC STAIR IN UNCONDITIONED SPACE

ROOF

- ☐ LIGHT COLORED
- ☐ RIDGE AND SOFFIT VENTS
- ☐ WIND POWERED TURBINE VENT

WINDOWS AND DOORS

- ☐ STORM SASH
- ☐ DOUBLE PANE
- ☐ FOAM CORE STEEL DOORS

HEATING AND COOLING SYSTEM

- ☐ INSULATED DUCTS
- ☐ TAPED DUCT JOINTS
- ☐ HEAT PUMP: _______ TONS
- ☐ SPLIT (ZONED) SYSTEM
- ☐ HIGH EFF. A/C _______ EER (MIN. 9.0)
- ☐ SET BACK TYPE THERMOSTAT
- ☐ ELECTRONIC IGNITION ON FURNACE
- ☐ TIMER SWITCH ON EXHAUST FAN
- ☐ SOLAR

FIREPLACE

- ☐ GLASS DOORS
- ☐ EXTERIOR COMBUSTION AIR
- ☐ CIRCULATING FIRLPLACE
- ☐ TIGHT-FITTING DAMPER

APPLIANCES & FIXTURES

- ☐ FLUORESCENT LIGHTS
- ☐ PILOTLESS IGNITION ON STOVE
- ☐ EXTRA INSUL. ON ELEC. WATER HEATER
- ☐ WATER-SAVING SHOWER HEAD
- ☐ LOW-FLUSH TOILET

OTHER ENERGY SAVERS

- ☐ OVERHANGS FOR SHADE — SOUTH SIDE
- ☐ GARAGE ON WEST SIDE FOR SHADE
- ☐ PORCH — EAST, WEST, OR SOUTH SIDE
- ☐ _______
- ☐ _______
- ☐ _______
- ☐ _______

BUILDER: _______________ **DATE:** _______

*From Building and Marketing the Energy Conserving Home in Georgia 1978-79.

RESIDENTIAL ENERGY CONSERVATION WORKSHEET

To determine where energy can be saved, it is necessary to determine where your present energy is going. To do this we need information on your present heating and cooling system and the construction of your house. Please complete the following questionnaire and bring it with you to the workshop along with a calculator.

I. PRESENT ENERGY BILLS

Plan # 2200
(Estimated Costs and Consumption)

	Electricity Cost	Electricity Kilowatt Hours (KWH)	Oil or Gas Cost	Oil or Gas Gallons (CCF)
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				
TOTAL				

Standard
$250 + $300 = $550   7,110 + 6,380 = 13,490 KWH

Energy Conserving
$125 + $205 = $330   3,570 + 4,330 = 7,900 KWH

II. HEATING/COOLING SYSTEM
(circle answer)

Heater type: oil gas heat pump resistance electric

Air conditioner: central room

Water heater: gas electric

Temperature setting: Winter day 70° Summer day ______

Winter night ______ Summer night ______

III. SIZE

After each element, give the area in square feet. If you have several different types of exterior walls or floors list each type separately.

Floor: $26 \times 42\frac{1}{2} = 1105$ sq.ft.

Ceiling: $26 \times 42\frac{1}{2} = 1105$ sq.ft.

Wall:
(exclude windows and doors)

Outside walls — Height — Upstairs wall above garage

$\left[(26 + 26 + 42\frac{1}{2} + 30) \times 16 + (12\frac{1}{2} \times 8) \right] -$

Windows — Glass door — Entry door

$\left[(18 \times 3\frac{1}{2} \times 3) + (3 \times 2\frac{1}{2} \times 3) + (6\frac{2}{3} \times 5) + (6\frac{2}{3} \times 3) \right] = 1827$ sq.ft.

Inside wall, next to garage — Door

$(12\frac{1}{2} \times 8) - (6\frac{2}{3} \times 3) = 80$ sq.ft.

Windows: $(18 \times 3\frac{1}{2} \times 3) + (3 \times 2\frac{1}{2} \times 2) + (6\frac{2}{3} \times 5) = 245$ sq.ft.

Doors: $2 \times 6\frac{2}{3} \times 3 = 40$ sq.ft.
Entry door and utility room door
Glass door on family room counted as window

Total heated volume:
(floor area times ceiling height) $2210 \times 8 = 17,680$

IV. CONSTRUCTION MATERIALS - R-VALUE

List the type of construction for each of the following parts of your house or house plans, in standard construction and in energy conserving construction. For each part list only those items that separate heated from unheated space, i.e., not interior walls or floors. Give the R-value for each item.

Floors:	Standard	Energy Conserving
Air film	0.92	0.92
Carpet	1.23	1.23
Sub floor	0.98	0.98
Building paper	0.06	0.06
Insultation (batt)		11.00
Air film	0.92	0.92
Total	4.11	15.11

Ceiling:	Standard	Energy Conserving
Air film	0.61	0.61
Gypsum board	0.56	0.56
Insultation	19.00	26.00
Airfilm	0.61	0.61
Total	20.78	27.78

Wall:		
Air film	0.17	0.17
Wood siding	0.81	0.81
Sheathing	2.04	2.04
Insultation (batt)	11.00	13.00
Insultation (rigid foam)		4.00
Finished wall	0.56	0.56
Air film	0.68	0.68
Total	15.26	21.26

Windows:		
Air film	0.17	0.17
Glass	0.89	
Storm window		1.79
Air film	0.68	0.68
Total	1.74	2.64

Doors:		
Air film	0.17	0.17
Wood door - 1 3/4"	2.17	
Metal insulated door		5.26
Air film	0.61	0.61
Total	2.95	6.04

V. TEMPERATURE DIFFERENTIAL (TD or ΔT^{o})

70° Temperature Inside Heated - 20° Temperature Outside = 50°

70° Temperature Inside Heated - 40° Temperature Inside Unheated = 30°

NC Cities	Outside Design Conditions Winter	Summer
Asheville	15	90
Charlotte	20	95
Elizabeth City	20	90
Greensboro/Winston-Salem	15	90
Greenville	20	95
Hickory	15	90
Raleigh	20	90
Wilmington	25	90

VI. Estimated Air Leakage or Infiltration (use chart on Handout #31, "Infiltration Factors").

Standard 1.25
Energy Conserving 0.75

The information on this worksheet can now be used to complete the heat loss calculations using the following formulas:

Calculate the heat loss in BTU/HR for each part of the house (floors, etc.) and total for the entire house:

$$\text{House Area (sq. ft.)} \times \frac{1}{\text{R-Value}} \times \Delta T^{o} = \text{Heat Loss BTU/HR}$$

Calculate infiltration:

$$.018 \times \text{Volume of house} \times \text{\# air changes per hour} \times \Delta T^{o} = \text{Infiltration Heat Loss}$$

To get total design heat loss add the total heat loss BTU/HR for house to the infiltration heat loss. A form has been provided for doing these calculations. ("Heat Loss in a Sample Standard and Energy Conserving House at Winter Design Temperature" Handout #32).

RESIDENTIAL ENERGY CONSERVATION WORKSHEET

To determine where energy can be saved, it is necessary to determine where your present energy is going. To do this we need information on your present heating and cooling system and the construction of your house. Please complete the following questionnaire and bring it with you to the workshop along with a calculator.

I. PRESENT ENERGY BILLS

	Electricity		Oil or Gas	
	Cost	Kilowatt Hours (KWH)	Cost	Gallons (CCF)
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				
TOTAL				
Standard				
Energy Conserving				

II. HEATING/COOLING SYSTEM
(circle answer)

Heater type: oil gas heat pump resistance electric

Air conditioner: central room

Water heater: gas electric

Temperature setting: Winter day ______ Summer day ______

Winter night ______ Summer night ______

III. SIZE

After each element, give the area in square feet. If you have several different types of exterior walls or floors list each type separately.

Floor:

Ceiling:

Wall:
(exclude windows
and doors)

Windows:

Doors:

Total heated volume:
(floor area times
ceiling height)

IV. CONSTRUCTION MATERIALS - R-VALUE

List the type of construction for each of the following parts of your house or house plans, in standard construction and in energy conserving construction. For each part list only those items that separate heated from unheated space, i.e., not interior walls or floors. Give the R-value for each item.

Floors:	Standard	Energy Conserving
Total		

Ceiling:	Standard	Energy Conserving
Total		

Wall:		
Total		

Windows:		
Total		

Doors:		
Total		

V. TEMPERATURE DIFFERENTIAL (TD or ΔT^o)

Temperature Inside Heated – Temperature Outside =

Temperature Inside Heated – Temperature Inside Unheated =

NC Cities	Outside Design Conditions Winter	Outside Design Conditions Summer
Asheville	15	90
Charlotte	20	95
Elizabeth City	20	90
Greensboro/Winston-Salem	15	90
Greenville	20	95
Hickory	15	90
Raleigh	20	90
Wilmington	25	90

VI. Estimated Air Leakage or Infiltration (use chart on Handout #31, "Infiltration Factors").

Standard ______________

Energy Conserving ______________

The information on this worksheet can now be used to complete the heat loss calculations using the following formulas:

Calculate the heat loss in BTU/HR for each part of the house (floors, etc.) and total for the entire house:

$$\text{House Area (sq. ft.)} \times \frac{1}{\text{R-Value}} \times \Delta T^o = \text{Heat Loss BTU/HR}$$

Calculate infiltration:

$$.018 \times \text{Volume of house} \times \text{\# air changes per hour} \times \Delta T^o = \text{Infiltration Heat Loss}$$

To get total design heat loss add the total heat loss BTU/HR for house to the infiltration heat loss. A form has been provided for doing these calculations. ("Heat Loss in a Sample S andard and Energy Conserving House at Winter Design Temperature" Handout #32).

PAGE 167 "RESISTANCE VALUES OF STRUCTURAL AND FINISH MATERIALS, INSULATIONS, AIR SPACES, AND SURFACE FILMS" REMOVED DUE TO COPYRIGHT RESTRICTIONS.

INFILTRATION FACTORS

Construction	Operation	Air change/hour
storm windows & doors very good caulking & weather-stripping	very careful not to leave doors & windows open	0.5
dbl glass, caulking & weather-stripping	careful	0.75
single glass, average fit on doors & windows	fair	1.5
loose windows & doors	fair	2.0
loose windows & doors	poor, e.g., many children	2.5+

infiltration heat load = .018 x bldg. volume x #air change/hour x temperature difference (inside - outside)

HEAT LOSS IN A SAMPLE STANDARD AND ENERGY CONSERVING HOUSE AT WINTER DESIGN TEMPERATURE

Description	House Area (sq. ft.)	x	1/R Value Standard	1/R Value Energy Conserving	x	ΔT^{o} [1]	=	Heat Loss BTU/HR Standard	Heat Loss BTU/HR Energy Conserving
1. Floors Over basement	1105		1/4.11	1/15.11		30		8055	2188
2. Ceiling/Roof	1105		1/20.78	1/27.78		30		1591	1193
3. Walls Outside	1827		1/15.26	1/21.26		50		6029	4291
Inside next to garage	80					30		158	113
4. Windows	245		1/1.74	1/2.64		50		7044	4642
5. Doors	20		1/2.95	1/6.04		50		339	166
	20					30		203	100
6. Infiltration (.018 x Volume x # air changes x ΔT^{o})									
Standard .018 x 17,680 x 1.25 x 45°[2] = 17,901								17,901	
Energy Conserving .018 x 17,680 x 0.75 x 45°[2] = 10,741									10,741
TOTAL DESIGN HEAT LOSS								41,320[3]	23,434[3]

1 The temperature difference (ΔT^{o}) is calculated based on 20° outside and an estimated 70° inside heated spaces and 40° inside unheated spaces.
2 This is an estimate of ΔT^{o} due to air infiltration to inside heated areas from both inside unheated spaces and outside.
3 This figure is approximate and compares to the heating load figure for the standard and energy conserving house plan in Handout #23.

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HANDOUT #32, p.1

HEAT LOSS IN A SAMPLE STANDARD AND ENERGY CONSERVING

HOUSE AT WINTER DESIGN TEMPERATURE

Description	House Area (sq. ft.)	x	$\frac{1}{\text{R Value}}$		x	ΔT^{o1}	=	Heat Loss BTU/HR	
			Standard	Energy Conserving				Standard	Energy Conserving
1. Floors									
2. Ceiling/Roof									
3. Walls									
4. Windows									
5. Doors									
6. Infiltration (.018 x Volume x # air changes x ΔT^o)									

TOTAL DESIGN HEAT LOSS

1 The temperature difference (ΔT^o) is calculated based on 20^o outside and an estimated 70^o inside heated spaces and 40^o inside unheated spaces.

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HANDOUT #32, P.2

ESTIMATING ANNUAL HEATING ENERGY CONSUMPTION

1. Calculate design heat load in BTU/HR and convert to BTU/DD.

   BTU/DD = (_______ BTU/HR x 24 hr) ÷ ΔT^{o}

2. Find annual heating load.

   BTU/yr = _________ BTU/DD x _________ DD/yr

NC Cities	Average Annual Heating Degree Days (DD/yr)
Asheville	4237
Cape Hatteras	2731
Charlotte	3218
Greensboro/Winston-Salem/High Point	3825
Greenville	3060
Hickory	3831
Raleigh	3514
Wilmington	2433

(Information available from National Climatic Center, Asheville, NC, (704) 258-2850).

3. Find actual energy used considering heater efficiency.

   Natural Gas CCF = ______ BTU/yr ÷ 100,000 ÷ efficiency [0.60 to 0.70(%)]

   Oil gal/yr = ______ BTU/yr ÷ 140,000 ÷ efficiency [0.60 to 0.70(%)]

   Electric KWH/yr = ________ BTU/yr ÷ 3410

   Heat Pump KWH/yr = ________ BTU/yr ÷ 3410 ÷ COP (1.75 to 2.50)

(Appliance efficiencies or COP are available from manufacturer).

4. Find annual heating cost.*

   Natural Gas $/yr = __________ CCF/yr x $0.35

   Oil $/yr = __________ gal/yr x $0.78

   Electric $/yr = __________ KWH/yr x $0.04

   Heat Pump $/yr = __________ KWH/yr x $0.04

*Fuel costs per unit, i.e., per CCF, gal or KWH, must be adjusted according to current rates. The figures given were approximate current costs at the time of publication.

PAGES 175-176 REMOVED DUE TO COPYRIGHT RESTRICTIONS.

DESIGN AND PLANNING FEATURES

- Compact rectangular plan minimizes heating and cooling loads
- Unconditioned vestibule/storage room buffers end wall
- Vestibule "air lock" entrance isolates conditioned space
- 7'-6" ceiling height reduces interior conditioned volume
- Family Retreat closes off for comfort conditioning
- Special circulator fireplace uses outdoor combustion air
- South-facing windows provide solar heating in winter
- Roof overhang designed to shade South-facing windows in summer
- Deciduous trees provide summer shading to South side of house
- North-facing windows reduced in size to 8% of floor area

EER HOUSE SPECIFICATIONS

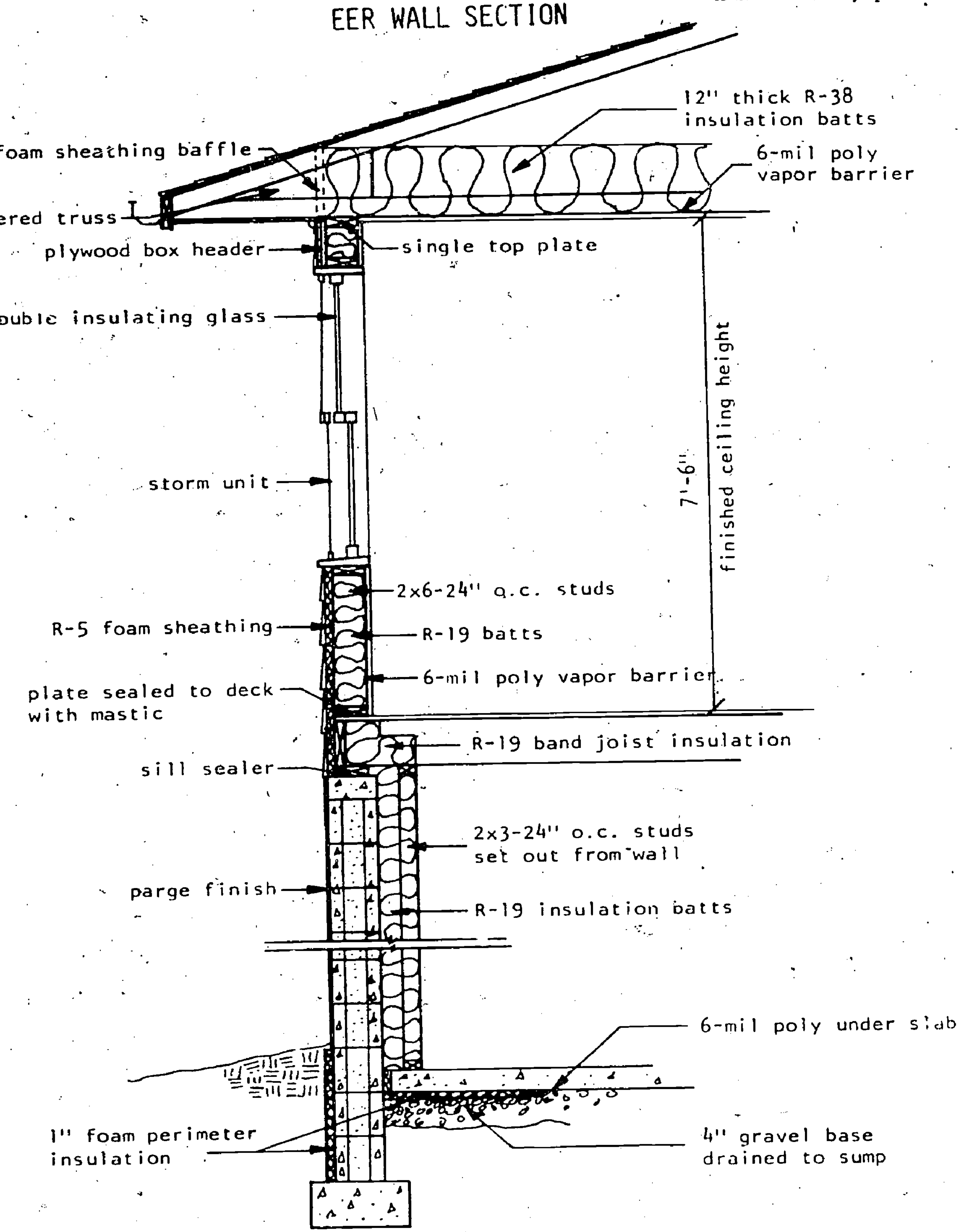
<u>Foundation/Floor</u>

- Dry basement construction with gravel and sump under slab
- 6-mil polyethylene film beneath slab and behind concrete block walls which are backfilled
- Exposed walls stucco-finished to seal concrete block against infiltration
- 2x3-24" o.c. studs set out from wall to accommodate insulation
- R-19 pressure fit insulation batts on exposed walls
- R-11 pressure fit insulation batts on below-grade walls
- 2" thick plastic foam perimeter insulation at exposed slab edges
- 1" glass fiber sill sealer between foundation and sill plate
- R-19 band joist insulation
- All utility entrances sealed with heavy caulk
- Basement storm windows

<u>Exterior Walls</u>

- Wall height of 7'-7" (nominal 7'-6" ceiling) to reduce interior volume
- 2x6 studs spaced at 24" o.c. with single top plate

EER WALL SECTION



Exterior Walls (continued)

- Bottom plate sealed to deck with construction adhesive
- R-19 unfaced pressure fit insulation batts in walls
- Continuous 6-mil polyethylene vapor barrier behind drywall
- R-5 plastic foam sheathing extends up between trusses, down over band joist
- Plywood box-header over openings insulated as walls
- 2-stud corner post with drywall backup clips to accommodate insulation at corner
- Partition posts deleted and drywall clips used to accommodate insulation at partition intersections
- Surface mounted electrical outlets with wiring in floor used to avoid penetrating wall

Doors/Windows

- Insulated steel entrance door with double glazing and magnetic weatherstrip
- Mechanical door closer on entrance door
- Insulated, weatherstripped inner vestibule door
- Interior doors permit closing off Family Retreat area for comfort conditioning
- Well-weatherstripped window units with double insulating glass plus storm windows (triple glazing)
- Insulating drapes used at windows to control winter heat loss and summer heat gain
- Cracks around door and window frames filled with insulation and sealed with poly
- Window area reduced to 8% of floor area except on properly shaded South orientation

Roof/Ceiling

- Standard trusses cantilevered over wall plate to provide clearance for insulation at exterior wall
- 12" thick R-38 pressure fit insulation batts installed from below
- Continuous 6-mil polyethylene vapor barrier below insulation
- Gable end vents provide 1 sq. ft. of ventilation for each 300 sq. ft. of ceiling
- 24" soffit overhang provides summer shading for South-facing windows
- Attic access door located in vestibule outside of conditioned area

Roof/Ceiling (continued)

- Surface mounted ceiling or wall mounted lighting fixtures to avoid penetrating ceiling

Heating/Cooling System

- Simplified duct system with low inside registers and low central return
- Special reduced-capacity heat pump with compressor installed indoors
- Controlled bypass on inside heat pump coil for improved summer dehumidification
- Heat exchanger on heat pump compressor to supplement domestic water heating
- Dehumidifier to control winter humidity without introducing outdoor air
- Manually controlled bathroom heaters for increased comfort in critical area
- Heat circulator fireplace unit with glass door enclosure uses outdoor combustion air
- Large South-facing windows in Family Retreat area contribute solar heating in winter

Water Heating/Appliances

- Heavily insulated water heater with isolated jacket set back to 120° F. temperature
- Hot and cold water pipes insulated to reduce heat loss, control condensation
- Low water use devices on kitchen faucet, bathroom faucets and shower heads
- High efficiency refrigerator with improved insulation, energy saving feature
- Electric range with heavily insulated standard oven plus microwave oven
- Energy saving dishwasher uses less water and air circulation drying
- Front loading clothes washer uses less water, has load size scale and selector switch
- Bathroom vent fans with effective damper, exhaust through second damper in exterior wall
- Fluorescent lighting four times as efficient as standard incandescent bulbs, used wherever appropriate

COMPARISON OF HEATING AND COOLING LOADS IN BTUH AT DESIGN TEMPERATURE CONDITIONS

Source	Heating		Cooling	
	Typical House	EER House	Typical House	EER House
Ceiling	4,610	2,130	4,170	1,640
Walls	5,510	2,730	2,600	1,240
Windows	6,170	3,290	6,430	5,600
Doors	1,650	260	800	550
Foundation	5,050	2,370	1,140	500
Infiltration	8,580	5,250	5,990	4,400
Internal Load	-	-	3,250	3,250
Total Heating Load	31,570	16,030		
Total Cooling Load			24,380	17,180

Note: Loads for "Typical House" represent a well insulated electrically heated home which meets or exceeds current standard practice.

PROJECTED ANNUAL ENERGY CONSUMPTION IN MILLIONS OF BTU'S

Energy Use	Typical House	EER House
Heating	67.2	14.5
Cooling	11.8	8.3
Hot Water	12.3	9.8
Appliances	15.2	13.0
Miscellaneous	13.5	13.0
Total Energy Use	120.0	58.6

Projected energy savings in EER house----61,400,000 Btu/year

Estimated savings on electric bills @ 3.5¢/Kwh----$630./year.

HOW MUCH ADDED COST TO THE HOME BUYER IS JUSTIFIED FOR ENERGY CONSERVING OPTIONS?

This question is best answered by determining the present value of anticipated savings on utility bills over a reasonable period of time. The present value of such future savings is primarily dependent on the rate of increase in energy costs which is assumed, and the number of years allowed to recoup the added cost of the energy conserving options.

Given an estimated savings in utility bills for the first year, the added investment justified for energy conserving options may be determined. The following table shows present values for future energy savings based on a savings of $630 in electric bills for the first year in the EER house, assuming a 9% finance cost. An annual rate of energy price increase of 10% to 12% and 5 to 7 years to recoup the investment are considered to be prudent assumptions for the near future.

Depending on the energy price increase assumed and the time allowed to recoup the cost, the values shown in this table provide a good indication of justifiable added cost for the Energy Efficient Residence from the home buyer's standpoint. Obviously, additional construction costs for the energy conserving options must be judged accordingly.

Additional Cost to Home Purchaser for Energy Conserving Options Justified by a First Year Savings of $630. in Utility Bills.

Annual Rate of increase in price of energy	Number of Years Allowed to Recoup Added Initial Cost of Energy Conserving Items			
	3	5	7	10
15%	$2,106	$3,710	$5,496	$8,560
12	1,996	3,420	4,923	7,337
10	1,925	3,238	4,575	6,627
8	1,856	3,064	4,251	5,991

WHAT IS THE ADDED COST OF EER ENERGY CONSERVING OPTIONS?

The total increase in cost attributable to the energy conserving options in the EER demonstration home is $5,382. On-site observations by industrial engineers indicates that less than 10% of this cost, or $507, is due to increased labor, while $4,875 is due to additional equipment and materials. Of the features used in the EER house, the increased ceiling and wall insulation and related framing modifications, thermally efficient windows and doors, high efficiency heat pump, heavily insulated water heater, heat circulating fireplace unit, and closed off family retreat show the greatest potential for energy conservation. These features would increase the cost of the home by only $2,258.

EER framing resulted in a net added cost of $101. The use of cantilevered trusses to provide additional clearance for insulation increased costs by $176, while the 2x6-24" o.c. wall framing with a single top plate and plywood box headers actually saved $75 compared with conventional 2x4-16" o.c. framing.

Increased insulation levels were obtained for an extra $1,075. Increased ceiling insulation accounted for 31% of this cost; greater wall insulation and plastic foam sheathing accounted for 23%. Basement insulation and related framing was the largest portion of this cost at 38%, and hot and cold water pipe insulation the smallest at 8%.

Thermally efficient windows and doors increased the cost by a total of $1,040. Well weatherstripped, triple glazed window units cost $949 more than standard wood units with storm windows. An additional $91 was required for insulated steel, magnetic weatherstripped doors compared to conventional wood exterior doors weatherstripped on site.

Floor plan modifications added a total of $1,224. The Family Retreat added only $185 to the cost of the house. The remaining $1,039 represents the cost of the vestibule "air lock" entrance and related modifications to the foundation, porch and roof.

Advanced mechanical systems added $1,014 to the cost of the EER house. Space heating systems including the heat pump, heat circulating fireplace and individual bath heaters cost a total of $388 more than an electric furnace with air conditioning and conventional masonry fireplace. Surface mounted electrical outlets installed in exterior walls cost $82 more than conventional outlets. The remaining $544 was for the heat recovery device used to heat domestic hot water with waste heat from the heat pump compressor.

Energy efficient appliances added $928. Approximately 63% of this cost was for the microwave oven, and 6% for a heavily insulated water heater. The remaining $286 was the added cost for energy conserving options on the refrigerator, dishwasher and clothes washer.

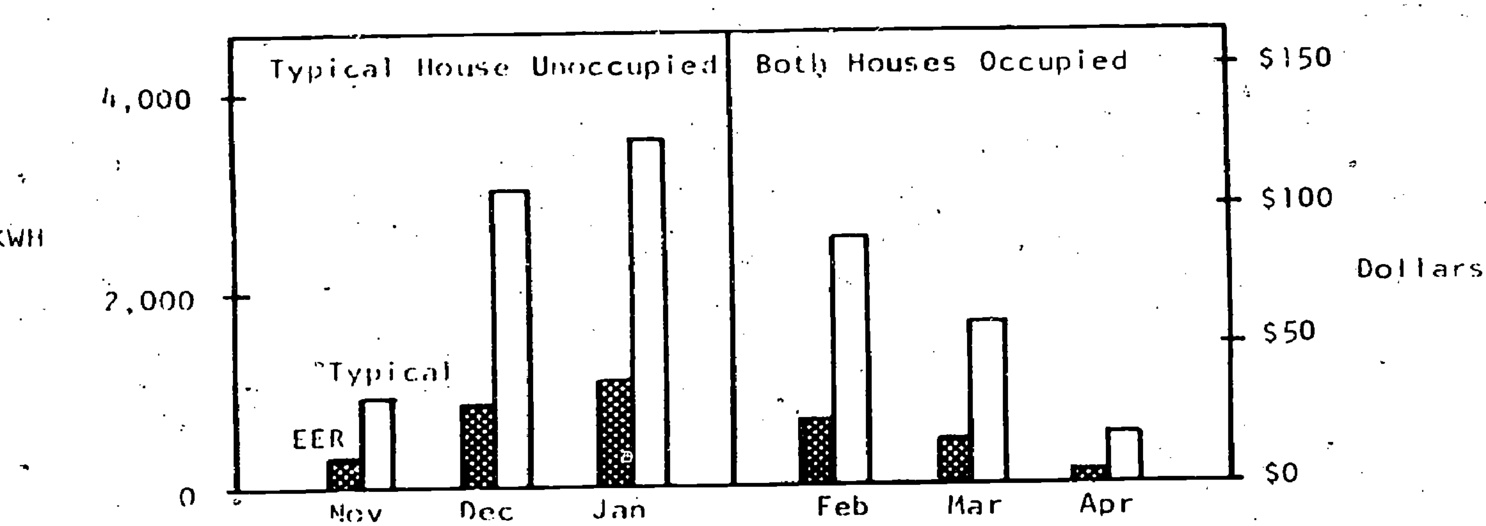
PRELIMINARY OBSERVATIONS ON THE SAVINGS RESULTING FROM EER ENERGY CONSERVING OPTIONS

Energy consumption for heating, cooling, water heating, major appliances and other uses is being monitored in both the EER house and a typical electrically heated home. Some preliminary observations provide an indication of the effectiveness of energy conserving options in the EER house. Power consumption for the winter months during which both homes were occupied is broken down in the following table. An overall savings of 57.0% was realized for the period of February through April 1978, which closely supports earlier projections. Heating was the greatest category of energy use in both homes and accounted for 75% of the total savings in the EER house. Monthly power consumptions for heating the two homes during the winter of 1977-1973 are compared in the graph below.

COMPARISON OF ELECTRIC CONSUMPTION IN KWH for the period February through April 1978

ENERGY USE	EER HOUSE	TYPICAL HOUSE	% SAVINGS
Space Heating	1313	4766	72.5%
Water Heating	1060	2090	49.3%
Appliances & Misc.	1110	1242	10.6%
Total	3483	8098	57.0%
Cost @ .035/Kwh	$121.91	$283.43	

COMPARISON OF ELECTRICITY CONSUMED FOR HEATING (Cost based on rate of $.035/Kwh)



PERFORMANCE REPORT: ENERGY EFFICIENT RESIDENCE VERSUS A TYPICAL HOUSE*

At the time of the report on the previous page, preliminary observations of the electricity consumption of the Energy Efficient Residence (EER) and a Typical House (TH) had only been done for the winter months of February, March and April. Later observations were made for the summer months of June, July and August. (The Typical House was the same model as the Energy Efficient Residence without alterations and additions for energy conservation.)

TABLE 1.

ELECTRICITY CONSUMPTION - KWH
HEATING AND COOLING ONLY

	Heating Feb., Mar., Apr.		Cooling Jun., Jul., Aug.	
	EER	TH	EER	TH
Projected	1670	7740	1703	2421
Actual	1313	4766	1117	2053
Difference	357	2974	586	368
% Difference	21.4	38.4	34.4	15.2

The information provided in Table 1 has not been adjusted for deviations from projected outside temperatures. The actual number of Degree Days for the winter was 9.7% higher than was projected for these three months; therefore, the performance of both houses was better than Table 1 indicates. The actual number of cooling hours is believed to be less than was projected; therefore, the performance of both houses may not be so far removed from the projected performance.

*Taken from Ralph J. Johnson and Orville G. Lee, <u>An Energy Efficient Residence - Performance and Cost</u>, Report presented at the Thermal Insulation Conference, cosponsored by the Department of Energy and ASTM Committee C-16, Tampa, Florida, October 23, 1978 (Washington, DC: National Association of Home Builders).

*Information reprinted with the permission of the National Association of Home Builders.

TABLE 2.

SUMMARY - ENERGY USE - KWH
FEB., MAR., APR.

Item	EER	TH	% Reduction (Increase)
Heat Pump Heating	953	-	
Resistance Heating	95	4606	
Blower	260	160	
Bath Resistance Heaters	5	-	
Subtotal Heating	1313	4766	72.4%
Water Heater	1060	2090	49.3%
Range	238	105	(126.6%)
Refrigerator	269	360	25.3%
Dishwasher*	30	10	--
Clothes Washer*	10	20	--
Clothes Dryer	174	284	38.7%
Lighting & Misc.	389	463	16.0%
Subtotal Appliances	1110	1242	10.6%
Subtotal W.H. and Appl.	2170	3332	34.9%
Total House	3483	8098	57.0%

*Dishwasher and clothes washer meters are X10, so a zero reading indicates less than 10 kwh of consumption.

Table 2 summarizes the energy use for the EER and TH for the winter months by heat pump or furnace, blower, water heater and individual appliances. Note the great reduction in energy used for water heating in the EER.

TABLE 3.

SUMMARY - ENERGY USE - KWH
JUN., JUL., AUG.

Item	EER	TH	% Reduction (Increase)
Heat Pump Cooling	832	-	-
A.C. Compressor	-	1755	52.6%
Blower	285	298	4.4%
Subtotal Cooling	1117	2053	45.6%
Water Heater	652	1483	56.0%
Range	207	99	(109.1%)
Refrigerator	252	495	49.1%
Dishwasher*	38	20	-
Clothes Washer*	14	27	-
Clothes Dryer	189	207	8.7%
Lighting & Misc.	515	323	(37.3%)
Subtotal Appliances	1215	1171	(3.6%)
Subtotal W.H. and Appl.	1867	2654	29.7%
Total House	2984	4707	36.6%

*Dishwasher and clothes washer meters are X10, so a zero reading indicates less than 10 Kwh of consumption.

Table 3 summarizes the energy use for the EER and TH for the summer months. Note again the great reduction in energy used for water heating. In addition, the water heater in the TH probably contributed to increasing the cooling load

Total energy use for heating and cooling for February through August was 2626 Kwh in the EER and 7088 Kwh in the TH, a reduction of 63%. (Note that this includes May usage not listed in the tables because there was both heating and cooling during that month. For May heating and cooling the EER used 196 Kwh and the TH used 269 Kwh.) The reduction of 63% is greater than the 51.1% that was projected for total annual savings for the EER.

It is important to note that standard load and use calculating procedures tends to overestimate both load and use for these homes. This results in oversizing equipment which costs more to install and operate, wastes energy and does not produce as comfortable an environment.

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SLIDE DESCRIPTIONS*

5 1. Insulation map (US).

5 2. R-value map - NC is in transition zone, better to add more.

5 3. List of R-values in wall, R=14.5, note that R's are added; substitute UF foam in wall for R-11 batt, this gives 15.8 or a 33% increase in the total for the wall.

5 4. Cut away of an R-14.5 wall - note that UF foam and/or High R sheathing could be substituted.

5 5. Look at R's, not inches.

*See page 3 for information on obtaining slides.

OTHER REFERENCES AND RESOURCES

1. Load Calculations for Residential Winter & Summer A/C: Manual J. Arlington, VA: National Environmental Systems Contractors Association.

   This guide is for calculating heating and cooling loads primarily for residential applications. It should be used on every job. Check for addendums that cover new energy conservation practices and materials.
   Available (about $4) from National Environmental Systems Contractors Association, 1501 Wilson Blvd., Arlington, VA 22209.

2. ASHRAE Handbook of Fundamentals. New York: ASHRAE.

   This guide is for heating engineers. It contains the theories behind the calculation procedures in Manual J and is used mostly for commercial, institutional, and industrial applications.
   Available (about $45) from ASHRAE, 345 East 47th St., New York, NY 10017.

3. Thermal Performance Guidelines for One and Two Family Dwellings. Washington, DC: National Association of Home Builders.

   Contains discussions and worksheets similar to those presented in this section but with more detail.
   Available (about $3) from NAHB, 15th and N, N.W., Washington, DC 20005.

4. McGowan, Thomas F., et al. Building and Marketing the Energy Conserving Home. Atlanta: Georgia Institute of Technology, 1978.

   Available from Georgia Office of Energy Resources, 270 Washington St., SW, Room 615, Atlanta, GA 30334.

5. Johnson, Ralph J. and Orville C. Lee. An Energy Efficient Residence - Performance and Cost. Report presented at the Thermal Insulation Conference, cosponsored by the Department of Energy and ASTM Committee C-16, Tampa, Florida, October 23, 1978. Washington, DC: National Association of Home Builders.

   This report contains a complete review of the performance of the Energy Efficient Residence compared to the same model without the energy conserving alterations and additions.

APPENDIX

Technical And Marketing Assistance

APPENDIX

Technical and Marketing Assistance

NC Department of Insurance Engineering Division Robert Wray or Lee Hauser 430 North Salisbury Street Raleigh, NC 27611 919/733-3901	Building code interpretation and update.
Owens Corning Fiberglas Donald Thomas Suite 207, 3200 Old Wake Forest Rd. P.O. Box 18107 Raleigh, NC 27609 919/872-0823	Technical and sales assistance - pamphlets, signs, etc.
Carolina Power and Light Dennis W. Carter, PE P.O. Box 1551 Raleigh, NC 27602 919/836-6539	Technical and sales assistance - pamphlets, signs, etc.
Rapco Foam Bob Adams 3001 Harvard Avenue Extension Durham, NC 27703 919/596-2127	Technical and sales assistance - pamphlets, signs, etc.
Duke Power Company Lee Clements Kroger Plaza Chapel Hill, NC 27514 919/967-8231	Technical and sales assistance - pamphlets, signs, etc.
Integrated Energy Systems, Inc. Daniel R. Koenigshofer 211 North Columbia Street Chapel Hill, NC 27514 919/942-2007	Architects and engineers specializing in energy.
North Carolina Home Builders Assoc. Nick De Mai 4300 Six Forks Rd. Raleigh, NC 919/782-3300	Technical and sales assistance. Referrals

National Solar Heating &
Cooling Information Center
P.O. Box 1607
Rockville, MD 20850
800/523-2929

Info on solar equipment, designers, sales & lots of free publications.

Daniels Enterprises, Inc.
P.O. Box 2370
La Habra, CA 90631
213/943-8883

Computer calculations of insulation, optimal tilt, performance, etc. Very reasonable and fast.

North Carolina Energy Division
Doug Culbreth, Energy Conservation
Lily Murdock, Solar
Dobbs Building
Raleigh, NC 27601
919/733-2540

Advice, pamphlets on state and federal programs

North Carolina Science Technology
Research Center
Leon Neal, Solar Specialist
Research Triangle Park, NC
919/549-0671

Keeps track of solar activity in NC. Excellent resource person.

Field Trip Suggestions

Fitch Creations
(Polks Landing, Fearrington)
R. B. Fitch
309 N. Greensboro St.
Carrboro, NC 27510
919/942-5107

Two large developments which have used energy conservation as their prime selling point and are selling very well.

Paul Trollinger
200 Worth St.
Asheboro, NC 27203
919/629-9144

Developments with 2 x 6 walls, all wood foundations, many energy saving features.

Solomon & Reuben Builders
Gary Lipson
209 N. Columbia St.
Chapel Hill, NC 27514
919/967-6082

Has built two full active solar homes, one on speculation. Has installed solar water heating on several others.

Space Builders, Inc.
(formerly affiliated with
Designworks)
Giles Blunden
403 Weaver St.
Carrboro, NC 27510
919/929-7072

Designed and built many innovative homes using passive solar features e.g., concrete, water, greenhouses, clerestories, and many other energy conserving features.